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The Technological and Socio-Economic Organization of the
Elmenteitan Early Herders in Southern Kenya (3000-1200 BP).

by

Steven Thomas Goldstein

A dissertation presented to
The Graduate School
of Washington University in
partial fulfillment of the
requirements for the degree
of Doctor of Philosophy

May 2017
St. Louis, Missouri

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Washington University in St. Louis

May 2017

ABSTRACT OF THE DISSERTATION

The Technological and Socio-Economic Organization of the
Elmenteitan Early Herders in Southern Kenya (3000-1200 BP).

by

Steven T. Goldstein

Doctor of Philosophy in Anthropology

Washington University in St. Louis, 2017

Professor Fiona B. Marshall, Chair.

Understanding how the modern world has been shaped by the origins and spread of food production deeper in our past is an enduring and fundamental goal of anthropological archaeology. In Africa, mobile pastoralism emerged as a way of life that is economically and ideologically focused on herding livestock, and spread across the continent over the last 8000 years. Despite the potential importance of African pastoralism within global dialogues on the origins of food production, the social and economic systems that sustained its spread through the continent remain poorly understood. A culture-complex known as the Elmenteitan is associated with the spread of stone-tool using herders into southern Kenya, and the development of a long-distance obsidian exchange system stemming from a single quarry site on top of Mt. Eburru from 3000-1400 years ago. This dissertation uses the Elmenteitan case-study to mount the first comprehensive study of how economic needs, environmental conditions, and socio-cultural institutions shaped ancient pastoralist technological strategies. To accomplish this I directed archaeological surveys and excavations at the Elmenteitan Obsidian Quarry on Mt. Eburru to test hypotheses regarding the social systems involved in herder obsidian procurement. I engaged in intensive analysis of stone

tool debris at the quarry in order to establish a start point for a larger comparative analysis of 12 lithic assemblages from Elmenteitan sites spread across southwestern Kenya. Based on archaeological and lithic datasets, I demonstrate that Elmenteitan herders deployed a regionally uniform lithic technology that emphasized flexibility in responding to environmental diversity and climatic change. I show that this form of technological organization was supported by a system of obsidian access and distribution that was maintained through investment in social institutions that bound Elmenteitan communities into a system of reciprocity, alliance, and cultural identity. I conclude that the integration of social, economic, and technological systems developed as strategy for ensuring long-term risk mitigation in unpredictable environments.

Chapter 1

INTRODUCTION

The development and spread of food production was among the most transformative processes in the human past. It has become clear that, like the origins of behavioral modernity (Conard 2012; d’Errico 2003; McBrearty and Brooks 2000), urbanism (Cowgill 2004; LaViolette and Fleisher 2005; McIntosh 2005) and social complexity (Crumley 1995; Frachetti 2012; Hayden 2014), the origins of food production involved complex and non-linear economic and cultural processes. Major social transformations are often necessary for the emergence and success of food-producing lifeways (Childe 1957; Marshall and Hildebrand 2002; Smith 2001; Zveilebel 2009). This is especially clear for lifeways based on mobile pastoralism, wherein economies and ideologies are centered on moving domesticated animals to communal pastures, and people respond to social or environmental challenges through mobility (R. Dyson-Hudson and N. Dyson-Hudson 1980). Globally, mobile pastoralism is also associated with complex information sharing and gift exchange networks, marriage alliances, and landscape level economic organization (Capriles 2011; Dahl and Hjort 1979; Denbow 1984; Frachetti 2009; Ingold 1980). Development of these social and economic systems helped pastoralism become one of the most productive and sustainable forms of food production in the world’s arid environments, but their origins are poorly understood.

In Africa, strategies of cattle-based pastoralism emerged before, and independent of, plant-based agriculture (Garcea 2004; Marshall and Hildebrand 2002; van der Veen 1999). This unique trajectory was influenced by increasing aridity in northern Africa, as the wet conditions of the African Humid Period began deteriorating after c. 7500 BP. As rainfall and grazing land became

more unpredictable, nascent herders became more mobile, leading to substantial dispersals of herder populations southward. People incorporated domesticated forms of goat and sheep that were adopted through exchange from the Near-East and Nile Valley, and eventually domesticated the donkey from a wild African ancestor (Marshall 2007). By 5000 years ago herders had reached northern East Africa, which provided a corridor for the eventual spread into southern Africa. Pastoral dispersals throughout the region were not easy. For the first time herders were separated from major river valleys and the more homogenous environments of early Holocene North Africa.

The pace and nature of climatic shift also made settling in eastern Africa more difficult. In eastern Africa they faced considerable heterogeneity formed by the Central Rift Valley, and a combination of arid grasslands, lakes-shores, steep escarpments, equatorial forests, and highland savannas. Just as herders entered these regions, the environments began changing rapidly due to ongoing climate change and the onset of the modern bi-modal rainfall regime (Ambrose and Sikes 1990; Garcin et al. 2011; Wright et al. 2015). Despite an initially patchy and delayed spread, herders eventually developed economic and social strategies that ensured their long term resilience to environmental unpredictability (Gifford-Gonzalez 1998a, 2002, 2015; Marshall 1994).

Artefactual evidence from pastoralist sites has played a fundamental role in constructing regional cultural-historical sequences (Ambrose 1982, 1983; Robertshaw 1990). To date, our understanding of the transition to pastoralism has been largely developed through zooarchaeological and genetic research that tracks the spread of domesticated livestock in the context of environmental change (Garcea 2004; Gifford-Gonzalez 2000; Hannote et al. 2002; Marshall and Hildebrand 2002). Studies of material culture, especially stone tools, have rarely been directed toward investigating social and economic strategies that herding societies developed in order to manage new challenges. In part, this is due to the long-standing view that African herder and

hunter-gatherer/forager lithic technologies are indistinguishable, save for a few typological traits or tool ratios (Lane 2004; Leakey 1931; C. Nelson 1973; Mehlman 1989). New perspectives and approaches provide opportunities to revisit these issues, and develop a more comprehensive understanding of the role of stone tool technologies in shaping the record for African food production.

Southern Kenya is one of the few regions in eastern Africa with a density and distribution of well-studied archaeological sites, and a comprehensive cultural framework, that permits a detailed empirical study of how lithic technological organization patterned the spread of herding in eastern Africa (Ambrose 1980, 1998, 2001; Bower 1991; Marshall 1990; Marshall et al. 2011; Robertshaw 1988). As pastoralists migrated into southern Kenya, they developed new technological and lithic procurement strategies to meet diverse ecological and social challenges. The mosaic of subsistence strategies and artifact typologies during this Pastoral Neolithic (PN) phase reflects the diversity in economic strategies and social systems in southern Kenya from c. 3200-1300 years ago (Ambrose 1984a; Bower and Nelson 1978). By comparison with the diverse entities that make up the Savanna Pastoral Neolithic (SPN), sites attributed to the “Elmenteitan” cultural-historical group are characterized by a highly cohesive set of material technologies, subsistence practices, and settlement strategies (Ambrose 1980, 1984a; Bower 1991). One of the most distinguishing traits of Elmenteitan sites spread across southern Kenya is a clear cultural preference for a very specific obsidian source on top of Mt. Eburru. Ambrose (2001: 201), Merrick and Brown (1980), and Robertshaw (1990) have suggested that the uniformity in Elmenteitan signatures resulted from integration within a regional system of obsidian exchange or distribution. Researchers seeking to lay foundations for understanding regional variability invoke this Elmenteitan pattern to discuss emerging social institutions and subsistence specialization within

the PN (Bower 1991; Gifford-Gonzalez 1998b, 2015; Robertshaw 1990:298; Simons 2005). The acquisition of obsidian and patterns of lithic production have played a critical role in framing models for PN exchange and potential social hierarchies, however investigations have not directly employed a study of lithic datasets to address these critical questions. Quantifying dimensions of Elmenteitan lithic production and distribution is therefore a necessary starting point for understanding the interplay of the proposed exchange networks, technological strategies, and social organization in ancient African pastoralist societies.

I approach this challenge with a single broad research question: What does the organization of lithic technologies reveal about the social, technological, and mobility strategies of early herders in eastern Africa? As a direct medium by which humans interact with their environment, lithic technologies must first and foremost be a successful means of coping with environmental challenges. Within environmental constraints, technological strategies are shaped by a myriad of social and economic considerations. By studying raw material acquisition, tool production, use, and discard, at a landscape level, it is possible to reconstruct the dimensions of early herder mobility and subsistence strategies that shaped lithic patterns. Economic strategies, including stone tool economies, also exist within a complex web of cultural values and social institutions. A careful study of lithic technology can also help reconstruct, or at least generate hypotheses for, aspects of prehistoric social organization. Here, I present a holistic archaeological case study of lithic technological organization among the “Elmenteitan” group of herders in southern Kenya as a first step forward in building a more complete model for the role of lithic technological strategies in the spread of early African pastoralists. I specifically aimed to test existing models for the control of the Elmenteitan Obsidian Quarry that fueled long distance obsidian exchange, the nature and consistency of that exchange, and the diversity of Elmenteitan technological signatures across the

landscape. This is the first study that brings together analytical, theoretical, and interpretative frameworks developed in other contexts to interpret a technological system in terms of the environmental, economic, and social circumstances of an eastern African herding society.

This dissertation is structured in eleven chapters. The second chapter discusses the origin and spread of pastoral lifeways in Africa and relates cultural-historical patterns, and also introduces the conceptual framework for the social and economic structures that distinguish recent African pastoralists. My aim in this chapter is to set out a range of strategies that have been important for the stability of recent herder lifeways, and to try and trace the evidence for the formation of these systems in the archaeological record. I then discuss the existing scholarship and hypotheses regarding Elmenteitan herders of southern Kenya with particular attention to obsidian acquisition, exchange, and lithic technology. Chapter Three lays out the theoretical and methodological approaches for the lithic analysis and interpretative frameworks used in this dissertation. I include an analytical framework for evaluating learning and detecting novices in the archaeological record as a bridge between the physical pattern of lithic debris, and the social circumstances that structured stone tool production, transportation, and use. I include an explicit discussion of my research questions, hypotheses, and archaeological expectations. In Chapter Four I discuss the research project itself introducing the environment, geology, human occupational history of the study area, and the focal site of the project—the Elmenteitan Obsidian Quarry (GsJj50)—on Mt. Eburru, Kenya as the start-point for the obsidian distribution system I aim to substantiate. Chapter Five presents archaeological and analytical methods, and my research design, which included surveys, excavations, and a broad-regional comparative study of lithic artifacts.

Chapter Six sets out results of the archaeological fieldwork at, and around, the Elmenteitan Obsidian Quarry. I report information on regional settlement patterns, spatial and activity patterns,

and site formation processes. It is here that I also report the lithic, ceramic, faunal, and other artefactual remains recovered from excavations, as well as the radiometric dates obtained for archaeological deposits. In Chapter Seven, I present a comprehensive analysis of technological and spatial patterns of core preparation and blade reduction at the Elmenteitan Obsidian Quarry. This chapter also discusses evidence for learning at the quarry site and data on production error rates. In Chapter Eight, I report the results of the regional comparative analysis of blade assemblages from 12 previously excavated Elmenteitan sites, the Elmenteitan quarry site, and the SPN site of Narosura. This chapter discusses the relative homogeneity in technological signature within the Elmenteitan, and highlights instances where there is deviation in specific variables or attributes.

In Chapter Nine I discuss the results of Chapter Eight as they relate to (1) reconstructing the nature of Elmenteitan obsidian exchange and distribution, (2) Elmenteitan technological organization, and (3) generating inferences on the nature of Elmenteitan mobility strategies. I argue Elmenteitan technologies across diverse environments demonstrate a similar organization that stresses the production of versatile tool-blanks from specialized core forms as a strategy for coping with the challenges of environmental unpredictability. This pattern would not be possible with a fairly consistent supply of obsidian, and Elmenteitan communities invested considerable time and energy into the social relationships necessary for maintaining access to obsidian from Mt. Eburru. Obsidian exchange and Elmenteitan technological organization are deeply intertwined, and reflect forms of risk mitigation that ensured the persistence of pastoralist lifeways in eastern Africa.

In Chapter Ten I discuss hypotheses laid out in earlier chapters in terms of how the quarry site was accessed and used as foundation for understanding broader Elmenteitan social institutions. I use survey data, spatial organization at the quarry, ceramic and faunal data, and reconstructions

of variation in core design and reduction sequences, and lithic toolkits derived from archaeological fieldwork, to refute the model of hierarchical control or management of the quarry presented by Robertshaw (1988, 1990). I present an alternative model that stresses communal access and cooperative use of the Elmenteitan Obsidian Quarry by Elmenteitan groups from across the landscape. The preliminary evidence for lithic learning is important for interpreting variability in lithic assemblages, and provide a foundation for discussing the ‘Communities of Practice’ involved in Elmenteitan obsidian quarrying and distribution. I use these theoretical framework as a platform to engage with broader issues regarding the socio-political organization of the Elmenteitan.

The eleventh and final chapter includes the major conclusions of this research project and its contributions to analytical methodologies, theoretical perspectives on pastoral archaeology, and the broader scholarship on the spread of food production in Africa. This dissertation is organized as a monograph that reports a large body of new quantitative data, and uses this information to inform models of pastoralist economic and social organization at different regional scales in the effort to address broad research questions regarding dispersal, and long-term sustainability, in eastern Africa.

Chapter 2

ARCHAEOLOGICAL AND ETHNOGRAPHIC APPROACHES TO AFRICAN PASTORALISM

2.1 Major questions

Trajectories of food production in eastern Africa involved a unique combination of bi-modal annual rainfall patterns, long term interactions with hunter-gatherers (and later farmers), independence from state level societies, and exploitation of spatially concentrated high quality lithic raw material sources. Major enduring questions on the spread of pastoralism relate to the economic organization and mobility strategies of early herding communities (Ambrose 1984a, 2001; Gifford-Gonzalez 2000, 2015; Marshall 1990, 2000; Prendergast 2009) and the social dimensions of herder lifeways (Ambrose 2001; Gifford-Gonzalez 1998a,b; Marshall et al. 2011). Addressing these questions has been challenging in light of the diverse subsistence strategies and artifact typologies that define the Pastoral Neolithic (PN), from c. 3300-1400 years ago (Ambrose 2001; Bower et al. 1977; Gifford-Gonzalez 1998a).

Research on the Elmenteitan lithic technological organization provides a rare opportunity for reconstructing Elmenteitan pastoralist lifeways and economic strategies. The communities that comprised the Elmenteitan culture group demonstrated a preference for obsidian from a single archaeological quarry site high on the slopes of Mt. Eburru for the vast majority of their stone tool production (Merrick and Brown 1984). Ambrose (2001: 201) and Robertshaw (1990) have argued that maintaining that pattern across 250 sq. km of southern Kenya required a socially organized system of exchange or distribution existing from c. 3000-1200 BP. This pattern is considerably different from technological patterns of any previous forager group (Ambrose 2012) in the region,

and is only comparable to the exchange systems of state-level societies. For this reason, Robertshaw (1990: 298) suggested some groups may have controlled obsidian access and distribution, fueling a form of inequality or social hierarchy. The pattern of obsidian acquisition, and distribution to Elmenteitan sites across southwestern Kenya, therefore, provides a bridge between the social and cultural institutions involved in exchange (Bower 1991; Robertshaw 1988, 1990; Simons 2005), and the technological strategies that developed in response to environmental constraints and economic necessities.

This dissertation attempts to grapple with these complex, multi-dimensional, issues by addressing each constituent part for the core research questions. First, what is the nature of access and use of the Elmenteitan Obsidian Quarry at the heart of the Elmenteitan exchange system? Second, what social institutions and forms of knowledge transmission contributed to the archaeological record for quarrying and obsidian distribution? Third, how did both the social institutions and the environmental and economic constraints of pastoral economies shape Elmenteitan technological organization, as understood by tracing lithic reduction strategies from the quarry source to sites in southwestern Kenya. I use these specific questions about the interplay between social management of exchange, technology, and environment as an entry point in working toward the much larger questions about the role of social change in the spread of herding in Africa.

2.2 The spread of mobile pastoralism in eastern Africa

Herding societies have participated in exchange to varying degrees from their origin in the ‘Green Sahara’ of the early Holocene to the modern day. When these systems developed and why, and how they were integrated into mobility and technological strategies, are lingering questions in

African pastoral archaeology (see Grillo 2014). It is important to understand the broad trajectories of pastoralism through time, and across the diverse environmental conditions of Holocene Africa, in order to begin discussing the inter-connected pattern of raw material access, exchange, mobility, and lithic technological organization of the Elmenteitan herders of southern Kenya.

2.2.1 Early Holocene origins

Trajectories of African pastoralism differ from those known for mobile pastoralism in Central Asia, the Andes, and the Levant, contributing valuable perspectives to global discussion of the origins and spread of food production. Most notably, African pastoralism developed 4,000-5,000 years before plant agriculture, and remained independent of agricultural lifeways in some parts of the continent until the last one-to-two millennia (Marshall and Hildebrand 2002; although see early evidence for Saharan plant use in Dunne et al. 2017). Strategies that arose and spread throughout the continent centered on the movement of domesticated cattle herds to pasture and their daily management. African herders also invested in multi-species herd management strategies with a mix of large and small stock. What really made African pastoralist lifeways globally unique was the prioritization of cattle and other livestock in the identities and ideologies of the herding societies (Galaty 1982; Smith 1986; Herskovits 1926). Another important feature of African herders, ancient and modern alike, is the reliance on complex networks of personal relationships and alliances to ensure long term resilience against climatic challenges.

African pastoralist lifeways developed in northern Africa between 10,000 and 8,000 BP based on current genetic and archaeological evidence. This places it within the African Humid Period (AHP), when northward shifts in the Inter-Tropical Convergence Zone (ITCZ) led to humid conditions across northern and eastern Africa following the hyper-arid Terminal Pleistocene

(Grove 1997:37; Hassan 1988; McGee et al. 2013). Increased rainfall fed the growth of Lake Megachad, Chotts Megalake, Ahnot-Moyer Megalake, and Lake Megafezzan, as well as riverine networks and the expansion of savanna grasslands that would have supported nascent experiments in keeping livestock (Drake et al. 2011; LeBlanc et al. 2006).

Potential evidence for long-distance cultural interactions include the widespread distribution of culture-historical traits: wavy-line pottery, microlithic tool-kits, and high rates of barbed bone point production at early Holocene sites across the Sahara and eastern Africa (Arkell 1972; Wendorf et al. 1985; Mohammed-Ali & Khabir 2003; Yellen 1998). These connections were made possible by the expanded river systems, and may reflect the emergence of subsistence strategies focused on aquatic resources (Barich 2002; Sutton 1977; Yellen 1998). Some of the apparent long-distance interactions may have been stimulated by population growth resulting from exploitation of abundant resources of the “Green Sahara”, and facilitated by the expansion of riverine networks (Kuper and Kropelin 2006; Manning and Timpson 2014). People began integrating delayed-return strategies into foraging ways of life, as well as the ideologies of personal ownership and wealth that likely accompanied them (Barich and Garcea 2008; Marshall and Hildebrand 2002). Conditions in the Sahara were primed for nascent food production.

People were experimenting with keeping Barbary sheep in Libya in the 9th millennium B.P., although this did not ultimately result in domestication (DiLernia 2001). In the eastern Sahara, intensive cattle management may have been underway by 10,000 BP based on the presence of *Bos* remains and an alleged well feature at the remote Egyptian site of Bir Kisieba (Close 1990, Gautier 1984; Wendorf et al. 1987). It is not until 7,700 BP that undisputed morphologically domesticated bovid remains begin appearing in western Egypt (Linseele 2004; MacDonald and MacDonald 2000). The origin of African cattle is still unclear, with some genetic evidence pointing to an

African domestication event (Bradley et al.1996; Bradley and Loftus 2000; Edwards et al. 2004; Grigson 2000; MacHugh et al. 1997; Perez-Pardal et al. 2010), and other molecular studies suggesting interbreeding between Eurasian cattle and African wild or domesticated cattle (Decker et al. 2015; Magee et al. 2014). By 7000 years ago, goats and sheep were introduced to pastoralist economies through the Sinai Peninsula. Even if domesticated cattle were primarily a Eurasian import, the management strategies and pastoralist lifeways that emerged in the Sahara were uniquely African.

In their earliest phases, these strategies are not thought to have included the mechanisms for building and maintaining exchange and resilience alliances. However, some scholars have argued that relatively sedentary hunter-gatherer populations had long been involved in interaction spheres spanning the arid tropical grasslands of the Sahara and Sahel based on the distribution of bone harpoon technology (Sutton 1974; Yellen 1998) and dotted-wavy-line styles of ceramics of the Khartoum Mesolithic tradition (Arkell 1949; Close 1995 Gifford-Gonzalez 2005). Although broad similarities in material culture and subsistence strategies are striking, there is little evidence for long distance movement of stone raw materials, or other information and material exchange systems. Evidence for violence in many pre-pastoral skeletal samples (e.g. Lahr et al. 2016; Wendorf 1968) and nearly exclusive use of local raw material sources (Beyin 2011; Cremaschi and Di Lernia 1999; Garcea 2005; Robbins 1974) in pre-pastoral periods reflect a persistence of more localized strategies, which at least in some cases were more competitive than cooperative.

More recent research emphasizes the distinctiveness of tool forms within regional traditions associated with the spread of herding, for example the Kiffian and Tenerian, further questioning ideas of monolithic and inter-connected Saharan “cultures” (Garcea 2013; Smith 1992). Economic commitment to exchange was casual, with more intensive investment in

network-building offering little benefit for relatively sedentary fisher-foragers who enjoyed a fair degree of self-sufficiency during the African Humid Period.

Not long after morphologically domesticated cattle begin to appear in the African record, (~7500 BP) regional rainfall began to decrease, ushering in the gradual (re-)desertification of the Sahara. Facing hyperaridity, populations de-emphasized aquatic adaptation in favor of new livestock management strategies (Marshall and Hildebrand 2002). Cattle, sheep, and goat, offered not only a portable source of meat, but also provided abundant calories in the form of milk. People in the Sahara were dairying by 7000 BP, as indicated by the presense of chemical residues in ceramic vessels (Dunne et al. 2012). Herders also became more mobile as wild plant stands and water sources diminished, as evidenced by thinning lenses of archaeological deposits and dung layers in Saharan rockshelters (Di Lernia 2002; Tafuri et al. 2006).

Increased pastoralist mobility reduced competition with groups who chose to remain hunter-gatherers, and appears to have facilitated the movement of stone beads and groundstone over thousands of kilometers (Clark 1970; McDonald 1992). Long distance connections has been temporarily established, but seemingly were not mantained. Herding was still risky and unstable, and several regions have evidence of intermittent pastoralist hiatus (McDonald 1998a,b). There is no archaeological evidence for the formation of consistent long distance exchange systems.

2.2.2 Mid-Holocene dispersals

Archaeologists often point to river valleys of the Saharan and to the Nile River Valley as avenues for herders moving southward into the Sudan, escaping deterioration of the African Humid Period in the Sahara (Barich 2002). Parts of the eastern and central Sahara were depopulated

between 5500-5000 BP as herders first began to appear in the Sahal and Sudan (Close 1992; Gautier 1987; Smith 1992).

Seasonal and permanent waterways were still prolific before 5000 BP, however the Nile corridor is considered one of the most viable corridors (Garcea 2004). It is certainly the most archaeologically visible pathway for the spread of herding, and it is the same route for the expansion of Nilotic speakers over the last 1000 years (Ehret 2001). Though the Nile is only one of many possible routes, it is perhaps the most important because its clustered resource distribution facilitated interactions between forager-fishers, cultivators, and pastoralists. The Nile was also a conduit for the introduction, and integration, of goats and sheep from the Near East. Small caprine stock reproduce roughly four times faster than do cattle, and herders began to incorporate small stock to better recover after the herd crashes that probably became increasingly common as ITCZ-fed rainfall systems shifted southward (Gautier 1987; Gifford et al. 1980).

Once south of the Sahara, herding expanded along a series of patchy and poorly defined frontiers. Several expansions of pastoralists moved through eastern Africa, fracturing off into multiple environments along the way. These regions were outside the natural distribution of wild cattle, presenting herders with new environmental and epizootic obstacles. The spread of herding was slow and patchy, and many communities continued to rely on wild resources (Marshall and Hildebrand 2002; Peters 1991).

Rock art has provided the primary evidence for early herding in the Horn of Africa, possibly reflecting the manifestation of ceremonial systems that tied together the disparate communities of early herders (Brandt and Carder 1987; Guthertz and Jallot 2011; Červíček 1979). Differences in the styles of rock art between the Sahara and the Horn might indicate migration was minimal, with local communities having adopted pastoral lifeways. There is, however, little

evidence for herders in the interior of Ethiopia before 4000 BP, and almost no sign of small stock until the Pre-Axumite period (Lesur et al. 2014; Marshall and Negash 2002). A coastal route around is probable (Lesur et al. 2014), although there are also very few dates for early domesticates from Djibouti or Somalia to support it at present (Brandt 1984; Brandt and Carder 1987; Gasse 2000). Early pastoralist communities in northeastern Africa were economically and socially diverse, probably shifting subsistence strategies frequently while remaining largely ephemeral in the archaeological record.

Low population densities of dispersed and mobile communities resulted in a patchy archaeological record. Coupled with limited research into early pastoralism in southern Sudan, southern Ethiopia, and Uganda, it is very difficult to trace the movement of food production into northern Kenya, the Central Rift Valley, and Lake Victoria basin. Western trajectories would have taken herders through equatorial forest ecologies that are far less hospitable for cattle. Dispersals into northern Uganda are feasible, but possibly required more cohesive social and economic organization to manage disease risk in bush and forest environments than had been needed further north (Gifford-Gonzalez 2000). Pioneer/frontier models (Ambrose 1984a: 236; Lane 2004) are, therefore, the most likely scenario at present, with small and loosely affiliated communities “leapfrogging” (after Rowley-Conwy 2011) southward to escape increasing aridity. Exchange and alliance systems may have arisen in particular times and places, but much as was the case in the Sahara, they were either too short-lived or small scale to be detectable in the archaeological record.

Figure 2.1. Dates for the earliest occurrences of domesticated cattle in Africa (after Marshall and Hildebrand 2002).

2.2.3 “Nderit” pastoralism in the northern Kenya (c. 5000-4000 BP)

Evidence for cattle based pastoralism first appears in the vicinity of Lake Turkana in Northern Kenya around 5000 BP, although the exact geographic direction(s) of transmission are still unclear (Hildebrand and Grillo 2012). This movement of herders into the region is currently understood as being still ephemeral and low-density, constituting a “Northern Exploratory Phase”

of pastoralism in East Africa (Marshall et al. 2011). Most of the evidence for early herding in the Turkana basin is tightly clustered around the paleo-lake shore in regions that had been densely occupied by forager-fishers during the African Humid Period (Phillipson 1977; Robbins 1974). The first true habitation sites with large proportions of domestic stock are GaJi2 and Dongodien (GaJi4), on the eastern side of Lake Turkana. Dongodien dates to around 4180 radiocarbon years ago, with a calibrated date that may indicate the site is as old as 4800 BP (Ashley et al. 2011). Unlike the Sudan or Central Rift Valley where domestic stock were included into continuous trajectories still focused on foraging, the early herders in Turkana relied more on sheep and goats, with some cattle, including limited fishing and limited hunting (Marshall et al. 1984).

Multiple lines of evidence suggest a migration of herding peoples into the northern Rift System near Turkana. An earlier period of low-scale pastoral interaction in the region is argued by Wright et al. (2015) on the basis of undated ceramic surface collections, however there are no direct dates on the materials or clear associations with domesticated fauna that would corroborate this hypothesis. Instead, the first dates for dedicated pastoral economies are contemporary with new lithic and ceramic traditions, and the appearance of unprecedented megalithic cemeteries.

The archaeological record for early pastoralism in Turkana provides the earliest evidence for herders developing a system of organized and sustained raw-material exchange that could be compared with the later Elmenteitan pattern. Ndiema et al. (2010) use geochemical sourcing data to propose that obsidian was transported from source groups north-east of the Lake to pastoralist sites around the Turkana Basin as a part of a long-distance exchange system. While blade and microlithic industries characterize most Later Stone Age industries, early herders around Turkana who had access to this obsidian produced a uniform technology featuring pyramidal blade cores (Figure 2.3) and large backed geometrics and truncations, that is notably different from early

forager toolkits that used local raw materials. Early herders also appear using a new style of highly decorated and internally scored pottery, called Nderit Ware. These material traits co-occur with early pastoralist habitation sites, and the megalithic mortuary sites marked by basalt pillars that also appear at the same time, and so they are attributed to the Nderit herders (Grillo and Hildebrand 2012). The organization necessary to construct monumental pillar sites offer another line of evidence for the formation of complex webs of social alliance among Nderit herders (Hildebrand et al. 2011). Communal engagement in constructing pillar sites was one means of bringing people together, and continuing use of the sites provided a venue for interactions that helped maintain ceramic styles and lithic technological strategies among disparate and highly mobile communities.

Early evidence for herding coincides with a period of rapidly diminishing lake levels in Turkana, as the ITCZ shifted southward, moving monsoonal rains away from the lake's major catchment zones in Ethiopia (Garcin et al. 2012). Lower rainfall rates would have presented one set of challenges to herders who depend on rain-fed pasture, however the recession of lakes may have opened large swaths of new grassland. Even lowered rainfall may have been enough to support lake-side grazing, providing an opportunity for a successful incursion of pastoralists. Eventually, increasing aridity after 4000 BP forced herders to either migrate out of Turkana, or abandon specialized herding economies (Grillo and Hildebrand 2013; Marshall et al. 2011). Additional terrestrial rainfall proxy records from micromammals, insects, and/or gastropods are needed, however, to better understand the local patterns of climate change.

Reconstructions based on modern regimes suggest that rainfall was highly patchy and unpredictable, with frequent droughts following ongoing fluctuations in the ITCZ and Congo Air Basin systems (Gillespie et al. 1984; Wright et al. 2015). Ethnohistoric pastoralists have managed to survive in even more intense aridity in the recent past, but benefited from complex alliance

systems, exchange networks, and an additional 2000 years of selection for drought tolerant and disease-resistant livestock (Fratkin 1998, 2001; McCabe 2004; Turton 1979). It is still not clear whether the earliest herders in northern Kenya had developed social and economic strategies that offered a comparable degree of resilience in the face of increasing aridity. However, early pastoralist settlement in the Lake Turkana was apparently not sustained.

Figure 2.2. Sites associated with early herders in the Lake Turkana Basin (c. 5000-4000 BP) and possible obsidian sources.

2.2.4 End of the NEP networks? (c. 4000 BP)

Evidence for long distance exchange virtually disappears after 4000 BP. Herding as an economic strategy persists, but it is ephemeral and people stopped constructing pillar sites (Grillo and Hildebrand 2013:198; Wright and Forman 2011). Other material traces associated with

pastoralism, including the predominance of Nderit ceramics and obsidian based blade industries, also largely disappear from Turkana at this time (Wright et al. 2015).

Migration remained one of the easiest options for pastoralists facing social or environmental problems, and the high altitude southern Rift system was significantly wetter and remained open to pastoralism. Some groups did likely move south as evidenced by small quantities of Nderit ceramics at Enkapune Ya Muto (4860 BP, see Ambrose 1998), Lukenya Hill (3290 BP), in the Serengeti (Bower and Chadderon 1986; Mehlman 1989:45), and in the Manyara Basin (3554 BP; Seitsonen 2006). There is only a very ephemeral trace of pastoralism in Central Kenya around Lake Baringo region, or on the Laikipia Plateau further south, until c.3000 BP, although much of this may be a function of research density.

2.3 The spread of pastoralism in southern Kenya

2.3.1 Hunter-gatherers in southern Kenya prior to pastoralism

Southern Kenya hosted several different hunter-gatherer economies in the Holocene that played an important role in structuring the initial spread of food-production into the region. Formally labeled the “Kenya Capsian”, the Eburran sequence is the best defined, beginning c. 12000 BP, and lasting until around 2000 BP, after over a millennium of Eburran forager co-existence with herder populations (Ambrose 1998). Eburran traditions are centered on Mt. Eburru, Kenya, with settlements in caves and rockshelters throughout the highlands of the Mau Escarpment and near the floor of the western Central Rift Valley (Ambrose 1984c). There is evidence for shifts in Eburran settlement strategies in response to climatic change (Ambrose 2001; Wilshaw 2016).

Eburran lithic traditions are divided into five phases, consistently defined by the production of very long and narrow backed microliths and geometrics, various scraper types, and narrow

blades with microfaceted preparation of wide striking platforms (Ambrose 1998, 2001). Phase V of the Eburran begins at 5000 BP with numerous changes that suggest contact with pastoralists from northern Kenya. Changes include the appearance of SPN ceramic styles, stone bowls, and construction of cairn burials like those at Gambles Cave (Leakey 1931) and Hyrax Hill (Leakey 1945). Caprines appear in Eburran levels by 4000 BP, and cattle appear at other sites after 3400 BP (Ambrose 1998; Marean 1992). Eburran lithic assemblages through this sequence are made exclusively on obsidians, but unlike the later herders, Eburran producers demonstrated no preference for particular obsidian sources within the Central Rift (Ambrose 2012; Merrick and Brown 1984).

Less well understood are the Holocene hunter gatherer traditions of south-central Kenya (although see Ambrose 1998 and Kusimba 2001 for discussion of Lukenya Hill), and the Kansyore fisher-forager traditions around Lake Victoria in southwestern Kenya. Like the Eburran groups, the lithic economies of these hunter-gatherers reflect a reliance on local raw materials with only small-scale involvement or access to long distance exchange (Ambrose 2012; Frahm et al. 2017).

Archaeological work around Lake Victoria provides evidence that the Kansyore groups living there also interacted with Elmenteitan pastoralists in the Later Holocene. Kansyore economies demonstrate a high reliance on aquatic resources including fish and shellfish, as well as local terrestrial mammals at open air and cave sites (Dale et al. 2004). They produced their own distinctive ceramic style and there is limited evidence of adoption of livestock before 2000 BP (Dale and Ashley 2010; Prendergast 2009). Kansyore groups had limited access to obsidian, and predominately used local quartzes for tool production. Evidence from Lake Victoria suggests that the Kansyore developed more cooperative and less competitive relationships with food producers than are suggested for the Eburran V (Ambrose 2001; Frahm et al. 2017). Hunter-gatherer groups

that had developed out of long Holocene traditions were deeply entrenched across southern Kenya by the time pastoralism begins to spread southward.

Figure 2.3. Pastoral Neolithic period sites in Kenya and northern Tanzania. See Table 2.1 for site names and cultural affiliations.

Table 2.1. Site names and affiliations for Figure 2.3 (above).

#	Site	Affil.	#	Site	Affil.	#	Site	Affil.
1	FwJj25/ FwJj5	Nderit	23	Masai Gorge	Elm. ¹	45	Wadh Lang'o	Elm. ³
2	GaJi2	Nderit	24	Enkapune ya Sauli	Elm. ¹	46	Gogo Falls	Elm. ³
3	Dongodien	Nderit	25	Enkapune ya Muto	Elm. ¹	47	Kansyore Island	Kan.
4	Jarigole	Nderit	26	Ndabibi	SPN	48	Siror	Kan.
5	Manemanya	Nderit	27	GtJi24	SPN	49	Usenge 3	Kan.
6	Lothagam N.	Nderit	28	Naivasha Railway	SPN	50	Rangong & Randhore	Kan.
7	Ngenyn	Nderit	29	Crescent Island	SPN ¹	51	Jawuoyo & Abindu	Kan.
8	Kisima	SPN	30	Oserian Quarry	SPN	52	Winam Gulf Sites	Kan.
9	Maringishu	SPN	31	Fisherman's Camp	SPN	53	Seronera	Nderit
10	Njoro R.C.	Elm.	32	Akira	SPN	54	SWRI	SPN
11	Deloraine	Elm.	33	Salasun	Nderit	55	Gol Kobjes	SPN
12	Hyrax Hill	SPN ¹	34	Suswa Lava Tubes	Elm.	56	Nasera	Nderit
13	Lion Hill Cave	Elm.	35	Sugenya	Elm.	57	Ngorongoro Burials	SPN
14	Bromhead's	Elm. ¹	36	Ngamuriak	Elm.	58	Maua Farm	SPN
15	Prolonged Drift	SPN ¹	37	Lemek NE	SPN	59	Wasendo	SPN
16	Nderit Drift	Nderit	38	Lemek NW	SPN	60	Mumba	SPN
17	Gambles Cave	Elm.	39	Regero	Elm.	61	Ishmijega	SPN
18	Prospect Farm	SPN	40	Sambo Ngige	Elm.	62	Mikocheni 1-2	SPN
19	Remnant	Elm.	41	Olopilukunya	Elm.	63	Jangwani & Gileodabeshta	
20	GsJj50	Elm.	42	Rotian	Elm.	64	Luxmanda	SPN
21	Gilgil	Elm.	43	Narosura	SPN			
22	Marula	Elm. ¹	44	Lukenya Hill	SPN ^{1,2}			

¹ Also has Eburran V deposits

² Nderit pottery

³ Also has Kansyore deposits

2.3.2 The initial spread of herding and hunter-gatherer interactions

The earliest evidence for specialized pastoral habitations in southern Kenya is preceded by a long period of sustained, but small scale, interactions between herders and foragers during the Mid-Holocene Dry Phase. Aridity drove a reduction of available grassland, likely impeding the expansion of herders in low-land savannas (Ambrose 2001). After their initial appearance in Eburran deposits in the Central Rift Valley, domesticated animals begin to appear around 3700 BP as far south as Tsavo and the Indian Ocean coast (Wright 2005, 2011). Isolated sheep and goat are also identified in the Lake Victoria Basin at the Kansyore fisher-forager sites of Usenge 3 and Gogo Falls in layers dated to between 3690 and 3300 BP (Dale and Ashley 2010; Lane et al. 2007;

Karenga-Munene 2002). Forager lithic technological signatures and settlement patterns remain unchanged during this period, making it unlikely that the presence of domesticates reflects decisions to pursue herding. Marshall (1994, 2000) suggests that these animals may be present at forager sites as a result of raiding or small scale exchange with herders. Social relationships between herders and local foragers may have laid the foundation for later, more formalized, exchange systems.

2.3.3 Climatic variability

Climate appears to be the actual driver for specialized pastoralism to spread through the Great Rift Valley and southern Highlands regions of Kenya. Arid conditions persisted in eastern Africa between 5000-3000 BP. Sediment cores show lake levels started to recover after 3300 BP (Garcin et al. 2012; Richardson and Dussinger 1987), at the same time Ambrose and Sikes (1991) identify a significant expansion of C4 savanna grasses. Sites with faunal evidence for more focused herding economies begin to appear in the Central Rift around this time, with the best example being the rockshelter site of Enkapune ya Muto (Ambrose 2001; Gifford-Gonzalez 1998; C. Nelson 1973).

There are several factors that likely contributed to the patchy spread of herding at this time. Evidence from lake core sedimentology in Lake Naivasha (Verschuren 2001), Mt. Kenya glacier activity (Karlen et al. 1999) and Kilimanjaro ice cores (Thompson et al. 2002) all indicate that despite overall improving conditions, rainfall patterns remained unpredictable on yearly, decadal, and centennial scales. Livestock diseases including malignant catarrhal fever, Rift Valley fever, East Coast fever, foot and mouth disease, and trypanosomiasis are endemic to the region, and may have further inhibited pastoralist dispersals as the climate was shifting (Gifford-Gonzalez

1998:190–95, 2015). Given the dense occupation of foragers already living in southern Kenya, cultural factors are also likely to have affected the rate and pattern of early herding (Gifford-Gonzalez 2000).

Early pastoralists faced climatic challenges similar to those faced by recent pastoralists. Droughts occurred on varying time scales, and the distribution of resources was unpredictable through space and time. The diverse pastoralist entities detected in southwestern Kenya in the Mid-to-Late Holocene may have emphasized community/family agency or overall cultural cohesion to different degrees in their responses to environmental unpredictability.

2.3.4 The Savanna Pastoral Neolithic (SPN)

After the slow trickle of domesticates southward, there is evidence for a first “wave” of herders into the region, as indicated by the coeval appearances of a common burial, settlement, and subsistence practices in highland savannas, but with highly diverse lithic and ceramic styles. Originally termed the “savanna-oriented Pastoral Neolithic”, the coarse similarities lead to a broad designation of “Savanna Pastoral Neolithic” (SPN) to describe this group of highly variable sites (Ambrose 1982, 1984, 2001; see also discussion of “PN” groups in Bower and Nelson 1978). This is in many ways a catch-all category that certainly includes several different social groups with slightly different economies and traditions, rather than a single culture-group. It is possible that the initial expansion of the various SPN sub-traditions reflects the migration of southern Cushitic speaking groups from Ethiopia proposed by historical linguistic reconstructions (Ambrose 1982). SPN sites first appear in the southern highlands of Kenya after 3300 BP, when arid conditions still predominated. These early occurrences are often associated with Eburran V lithic toolkits (Ambrose 1998, 2001). Sustained interactions between herders and hunter-gatherers is apparent,

especially at Crescent Island on Lake Naivasha where there are nearby and contemporaneous SPN and Eburran occupations (Onyango-Abuje 1977). Mary Leakey (1945) suggested that some local adoption of pastoralism may have occurred as well, based on her excavations of a pastoral midden with Eburran V artifacts and mortuary complex at Hyrax Hill (Ambrose 1984a).

SPN sites include a range of subsistence economies centered on domesticated cattle, sheep, and goat, and also a range of wild animals (Marshall 1990). There is no consistent SPN signature, with high ratios of wild fauna at the Crescent Island (Onyango-Abuje 1977) and Prolonged Dirft (Gifford et al. 1980), and more specialized herding possible at the large village of Narosura (Odner 1972). Macrobotanical remains have not been identified from existing SPN sites, and isotopic studies of human skeletal material by Ambrose and DeNiro (1987) are interpreted to reflect generally low consumption of plant foods by the SPN producers. Some degree of small scale cultivation of wild or even domesticated plants is possible (see Ehret 1974).

Archaeological sites are distributed from the Tsavo region of Kenya in the east to at least the Loita-Mara plains in the west (Gifford-Gonzalez 1998; Wright 2005). SPN traditions are bounded by Lake Baringo as the absolute northern barrier, however the southern extent is more problematic. Surveys and collections by Bower et al. (1977) and Mehlman (1989) suggest sites with SPN style lithics and Narosura ceramics dotted the Serengeti and Lake Eyasi regions of central Tanzania. Other sites, like the rockshelters of Mumba and Nasera show SPN ceramics and possibly livestock in association with more variable lithic technologies. Recent excavations at the site of Luxmanda on the Mbulu Plateau of north-central Tanzania present the first evidence for large PN habitation sites south of Ngorongoro Crater and Mt. Kilimanjaro (Prendergast et al. 2013). With an entirely Narosura style ceramic assemblage, presence of domesticates, small amounts of obsidian from known SPN quarry sites around Lake Naivasha, and basal dates at 3000

cal. BP, Luxmanda reflects a thriving SPN tradition in a highland environment. Burial sites with stone bowls and SPN material culture distributed from Baringo, through the Central Rift Valley, and in northern Tanzania consistently involve cairns, suggesting similarities in ritual practice or social organization (Ambrose 2001).

Herders of the SPN group in southern Kenya are responsible for a wide array of ceramic traditions, including Akira, Maringishu, and Narosura, although Ileret and Nderit vessels (more common in the Turkana region) have been reported as well (Ambrose 2001; Robertshaw and Collett 1983; Wandibba 1980). Ceramic styles are defined largely on organization of motifs within bands near the rims of vessels, and technical method of decoration, although vessel thickness is also sometimes used in defining types (Bower and Nelson 1978; Wandibba 1980). Exact definitions vary analyst-to-analyst, and are perhaps best combined into a single “Narosura” category, named after the large SPN settlement site (Robertshaw and Collett 1983). Narosura pottery is the most common SPN style outside of the Rift Valley. Akira pottery (formally “Thin-Incised-Paneled Ware” [Bower et al. 1977]) is more specialized, and appears at SPN and also some Elmenteitan sites. Robertshaw (1988, 1990) has suggested that Akira ware may have been produced by hunter-gatherers for exchange (either themselves or as a container for trade goods like honey).

From the perspective of lithic technological organization, it is difficult to describe a operational sequence that typifies a single site, much less a generalized technological pattern for the whole of the SPN. In general the SPN toolkit is similar to other LSA industries, but with generally shorter blades (<10 cm), small and very steep-faced endscrapers, and larger backed geometric microliths (Ambrose 1984, 2002; Goldstein 2014; Goldstein and Shaffer 2016). Stone bowls are common surface finds at open air SPN sites, but are also known from cave and

rockshelter contexts (Bower 1991). Stone axes, possibly for shaping cattle horns, occur at some sites, but are far rarer. Significant lithic diversity has been noted by many scholars, and may reflect regional adaptations of herders and/or the technical traditions of foragers who adopted pastoralism (Ambrose 1980; Gifford-Gonzalez 1988:183-184; Mehlman 1989; Nelson 1973). The SPN covers a highly diverse set of archaeological assemblages, which encompass a range of emergent lifeways involving herding. The term may, however, find purpose in referring to a loose network of interaction and exchange that separates these sites from those of other herders or foragers (Ambrose 2001).

One of the few unifying elements of the SPN is the reliance on grey obsidians acquired from the south and south-west Lake Naivasha Basin source groups (Merrick and Brown 1984, 1990). Producers of the SPN traditions were willing to use diverse raw materials, but a clear preference for Naivasha Basin obsidians begins early in the Pastoral Neolithic of southern Kenya and lasts until the Iron Age. Two sites, GsJi24 and the Fishermans Camp Quarry served as large-scale obsidian extraction sites for SPN producers, and many other obsidian sources were used by Eburran producing hunter-gatherers (Ambrose 2012). Visual inspection of the Naivasha basins obsidians (grey in hue) suggests these are fairly high-quality sources, without major flaws, crystobolites, gas pockets, or inclusions. Quality alone fails to explain why Elmenteitan peoples generally avoided these sources in favor of the Eburru source groups.

Localized lithic traditions are commonly interpreted as adaptations to specific ecological conditions, and the maintenance of these “styles” through time would, from a traditional lithic analytical framework, indicate more limited regional mobility (see Andrefsky 2012; M. Nelson 1991). Therefore, the movement of obsidians is best explained through sustained regional exchange. The nature of obsidian exchange is, like most aspects of the SPN, quite variable.

Prepared and partially prepared cores were being imported to some sites within 80 km west of the Central Rift sources - like Narosura, Lukenya Hill, and Lemek NE, as evidenced by high rates of cortex on obsidian debris (Odner 1972; pers. obs.). Even so, local quartz and chert dominates all SPN lithic assemblages outside of the Central Rift Valley. Some sites in the Serengeti and Tsavo have only a few blades and finished tools on non-local obsidian (Bower 1977; Robertshaw 1990).

Figure 2.4. Examples of typical Narosura style ceramics from Narosura type site.

Long-distance relationships existed, but varied in consistency and volume of episodes of exchange. Large ratios of obsidian artifacts at the SPN site of Maua Farm on Mt. Kilimanjaro suggest that people within 200 km of the Central Rift had access to regional exchange networks (Mturi 1986). Tendrils of these informal networks extended at least another 200 km further south to Mumba, Nasera, and the Luxmanda site in Tanzania, where excavations have found small quantities of obsidian sourced to the main SPN quarries (Prendergast and Grillo 2013, 2014). A significant drop-off in access at distances over 200 km is consistent with expectations for inform

down-the-line exchange models (Renfrew 1977). Stock-friendships and other interpersonal relationships between intermediaries in northern Tanzania and populations further south are the most likely cause for the archaeological pattern. How exactly these relationships coalesced, and their role within broader systems of economic security is still unclear. Most interestingly, throughout almost the entire period during which SPN groups were acquiring obsidians from Lake Naivasha sources, another group of herders with distinctly non-SPN traditions were exploiting an entirely different set of sources on Mt. Eburru.

2.4 The Elmenteitan tradition of the Pastoral Neolithic

2.4.1 Origins and comparison to the SPN

After 3000 BP, a distinctly new and more coherent material culture tradition emerged in the southern plains of Kenya. Louis Leakey first defined the Elmenteitan lithic industry on the basis of tool forms and their proportions within assemblages from the Central Rift Valley (Leakey 1931: 172-175). Expanded work found that these assemblages were associated with evidence for early food production, specific techniques of blade segmentation, and an undecorated, mica-tempered, ceramic style with lugs and spouts that differs markedly from any of the SPN styles (C. Nelson 1980; Wandibba 1980). Ambrose (1984b) has also defined consistent settlement patterns, technological characteristics, and burial practices involving cremation for the Elmenteitan (discussed below). Despite the major differences in material signatures, the Elmenteitan and SPN overlap across many parts of the Central Rift Valley and southwestern highlands of Kenya for almost 2000 years. During this time there is very little evidence for interaction between these groups, with the possible exception of Elmenteitan ceramic styles appearing at the site of Prolonged Drift, where SPN and “Wilton” forager styles dominate (Ambrose 1984c).

Figure 2.5. Map of regions, select Pastoral Neolithic open air settlements, and PN obsidian sources mentioned in text. After Goldstein 2014.

Based on the occurrence of dental avulsion in some individuals from Elmenteitan burial sites, Ambrose (1982) also argues that the Elmenteitan represent the initial spread of southern Nilotic speaking groups into southwestern Kenya. This would constitute the second “wave” of pastoralist migrations into the region, although the exact direction from which they entered southern Kenya remains unclear.

2.4.2 Elmenteitan chronology and subsistence

The earliest known appearance of Elmenteitan materials may date to 3000 BP at Njoro River Cave in the Central Rift Valley. However, the limited material culture at this cremation-

burial site does not easily fit current stylistic criteria for this assemblage group (see Leakey and Leakey 1950). The deposits in the cave were also disturbed, and associations are unclear (Merrick and Monaghan 1984). A more substantial problem is that well dated habitation sites like Masai Gorge in the Central Rift Valley (Ambrose 1982), and sites in the Lemek Valley in the Loita Mara plains (Robertshaw 1990) do not appear until around 2500 BP. Most of these were excavated and dated before the advent of more precise AMS dating procedures or radiocarbon calibrations (but see discussion in Ambrose 1998). This makes it difficult to assess temporal variability within the Elmenteitan sequence, although there has been some speculation on diachronic change (see below).

Table 2.2. Culture History of the Pastoral Neolithic in southwestern Kenya

<u>Tradition</u>	<u>Distribution</u>	<u>Subsistence</u>	<u>Material Culture</u>	<u>Cultural Features</u>
Elmenteitan 3000-1200 BP	Highland western and southwestern Kenya, Loita-Mara plains, western central Rift. ¹	Specialized cattle, caprine pastoralism.	Large flat blades w/ dorsal-proximal faceting on platforms, strangulated and notched blades, endscrapers, small geometrics, lugged/spouted ceramics w/ mica temper. Use of green obsidian from Mt. Eburru.	Possible Nilo-Saharan linguistic affiliation, cremation burials in caves and rock-shelters, interaction with Kansyore groups.
Savanna Pastoral Neolithic (SPN) 3300-1200 BP	Highland central and southwestern Kenya, Serengeti and Mbulu Plateau, Tanzania.	Specialized cattle, caprine pastoralism and hunting.	Blades with ground platforms, steep scrapers, large geometrics, diverse ceramic groups (Narosura, Maringishu, Akira, Ileret, Nderit), stone bowls. Use of obsidian from various Naivasha basin sources.	Possible southern Cushitic linguistic affiliation, burial in cairns, interaction with Eburran groups,
Eburran V	Naivasha and Nakuru basins, Central Rift	Hunting/gathering, gradual adoption of livestock.	Long narrow blades with microfaceted platforms, retouched and elongate geometrics, various scrapers, ceramics include Akira, Salasun, and Maringishu, stone bowls.	Cairn burials, interaction with PN groups (avoidance/competition with Elmenteitan ²)
Late Kansyore 3000- ? BP	Lake Victoria	Hunting/gathering/fishing, possible adoption of livestock.	Quartz lithic industry, Kansyore style ceramics.	Shell-midden burials, interaction with Elmenteitan groups.

¹ All Rift site are caves and rockshelters, southwestern highland sites are open-air.

² Ambrose 2001

Larger Elmenteitan sites like Ngamuriak and Remnant appear later in time and may reflect the emergence of specialized pastoralism, as permitted by a more predictable and higher volume bi-modal rainfall regime in southwestern Kenya (Bower 1991: 70; Marshall 1990). Indeed, several of the Elmenteitan sites in the southern highlands have yielded almost exclusively domesticated fauna (Marshall 1990; Simons 2004). Isotopic analyses on faunal remains conducted by Balasse and Ambrose (2005) indicate that groups living at lower elevations were not grazing livestock on highland grasses, suggesting altitudinal mobility was not a major Elmenteitan strategy.

Figure 2.6. Distribution of known Elmenteitan and select SPN sites in southwestern Kenya (Left). (1) Gogo Falls, (2), Oldorotua 1, (3) Oldorotua 5, (4), Regero, (5) Ngamuriak, (6) Olopilukunya, (7) GvJh 73, (8) GvJh 85 and 86, (9) Rotian, (10) Elburgon, (11) Njoro River Cave, (12) Lion Hill, (13) Bromheads Cave, (14) Gambles Cave, (15) Remnant, (16) GtJi10, (17) Marula (18) Enkapune Ya Muto, (19) Suswa Lava Tubes, (20) Elmenteitan Obsidian Quarry, (24) Wadh Lang'o; Select SPN sites; (21) Sonanchi Quarry Site, (22) Prolonged Drift, (23) Narosura. Box A (top right): Central Great Rift Valley showing documented obsidian sources (grey circles) and location of GsJj50 Elmenteitan obsidian source (red star) (source locations from Brown et al. 2013). Box B (bottom right): Elevation transect for the southern Rift (after Ambrose and DeNiro 1986b)

Sites near Lake Victoria like Gogo Falls and Wadh Lang'o deviate from the highland pattern, with a larger proportion of wild fauna (Lane et al. 2007; Robertshaw 1991). Wild resource utilization in these areas was thought to be a sign that herders were facing economic and environmental stress as they expanded into areas of high zoonotic risk and reduced grassland (Gifford-Gonzalez 1998a; Marshall 1994). Chritz et al. (2014) argue for more open ecologies near Victoria, and thus overall lower disease risk, based on recent isotopic analysis of fauna from the Elmenteitan site of Gogo Falls. This site sits on isolated soils that supports a patch of Mara-like grasslands, and could be an exception to an otherwise bush-dominant ecology of that region (Ambrose 2001: 104). Integration of wild fauna at these sites, they suggest, could be interpreted in the context of interaction with local fisher-foragers.

Robertshaw (1988: 63, 1990: 296) takes a different perspective, suggesting that site size variation may be due to settlement hierarchy, rather than purely diachronic change (see below). He also points to evidence of grindstones at both earlier and later sites to suggest more intensive exploitation of plant resources in Elmenteitan economies (Robertshaw and Collett 1983). Nitrogen isotope data derived from suspected Elmenteitan human remains supports this model by proposing higher plant food input into Elmenteitan diets (Ambrose and DeNiro 1986a).

Ambrose (1982: 236) points out that agriculture would have been unreliable in the past, and Marshall (1990) argues that the large and diverse herd structures, age at death patterns, intensive processing, and evidence for milking suggests the Elmenteitan were specialized pastoralists. Small scale cultivation may have been a consistently important dimension of the Elmenteitan subsistence strategy, although this has been difficult to detect archaeologically. Preparation of human and veterinary medicines is an additional, para-subsistence, dimension of plant and grindstone use that remains under-explored in Pastoral Neolithic settings (see Grillo

2014: 102). Macro-botanical evidence for domesticated plants does not appear until near the end of the Pastoral Neolithic, and seems to be strongly associated with the spread of iron technology (Robertshaw and Wetterstrom 1989).

Figure 2.7. Typical Elmenteitan style pot with spout from Ngamuriak.

It was the spread of iron technology that eventually led to the abandonment of many aspects of Pastoral Neolithic material culture and practices. The apparently simultaneous incursion of strategies involving iron, agriculture, and Urewe style ceramics occurred around Lake Victoria between 1800 and 1500 BP (Clist 1987; Karenga-Münene 2002; Lane 2004). Several Elmenteitan horizons in the area are directly overlain with Urewe bearing deposits (Lane 2004; Lane et al. 2007). A shift into a “Pastoral Iron Age” in the Central Rift Valley is evident at Deloraine Farm and Enkapune ya Muto slightly later, around 1300 BP. (Ambrose 1984b, 1998; Sutton 1993). A “transitional” phase at Deloraine Farm may reflect the last gasp of hallmark Elmenteitan traditions and an increasing emphasis on cereal cultivation and processing (Sutton 1993: 123). Lithics from

Deloraine Farm site show people were abandoning previous technological strategies in favor of more expedient tool production as iron was entering common use (Ambrose 1984b).

2.4.3 Settlement patterns

Elmenteitan sites overlap much of the same range as the SPN, but with a notably divergent settlement structure. Open-air occupation sites with Elmenteitan material culture tended to be found in highland areas, especially across the southwestern Kenyan highlands, but also at the Remnant site on the Mau Escarpment (Ambrose 1984a, 2001). Elmenteitan sites in the Central Rift are generally restricted to caves and rockshelters, and include mortuary sites like Gamble's Cave II, Bromhead's Cave, and Njoro River Cave. Geographic ranges for Elmenteitan sites overlap with those of the SPN in parts of the Central Rift and southern highlands, however the Elmenteitan seems to have extended further west to Lake Victoria (Figure 2.6) (Ambrose 1984a; Lane *et al.* 2007; Robertshaw *et al.* 1990). Conversely, SPN sites are represented much further south into north-central Tanzania, whereas there is no evidence that the Elmenteitan penetrated even so far south as the Serengeti Plain (Prendergast *et al.* 2013).

The co-occurring sets of material culture that would eventually come to define the "Elmenteitan" assemblage group were first defined from type sites in the Central Rift Valley. Early excavations by Louis and Mary Leakey at Bromhead's Site and Njoro River Cave produced evidence of heavily utilized, blade industries in association with largely undecorated lugged and spouted ceramics (Figure 2.7), human remains, and stone bowls (Leakey 1931; Leakey and Leakey 1950). Cohen (1970) and Sutton (1966) argued that these sites were at best technologically interesting examples of a more broadly defined "Stone Bowl Culture", which was tentatively associated with early food production in Kenya.

Excavations at Enkapune Ya Muto, Enkapune Ya Sauli, and Masai Gorge helped reestablish the Elmenteitan as a separate and cohesive entity (Ambrose 1985, 1998). Mortuary deposits associated with Elmenteitan material culture at Rigo Cave, Suswa Lava Tubes, and Lion Hill also demonstrated similarities with the Elmenteitan burial sites excavated by the Leakeys (Ambrose 1984b; Bower et al. 1977; Wandibba 1983). Some of these demonstrate considerable ritual investment, particularly Njoro River Cave where 78 stone bowls, 78 pestles, 77 grindstones, and over 500 ceramic sherds were collected in rough association with the cremation burials of around 80 individuals. Given that pastoralists are unlikely to keep livestock in caves and rockshelters except in extreme circumstances (Mutundu 1998), that many Elmenteitan sites are ritual in nature, and that there few reported open air Elmenteitan settlement sites in the Central Rift, Elmenteitan activities in this region may have had more to do with social circumstances than subsistence.

It is likely that majority of Elmenteitan residential occupations were concentrated in the rich grasslands of the southwestern Kenyan highlands. Excavations at the large settlement site of Ngamuriak on the Lemek River, and at Olopilokunya at the edge of the Loita Hills hint at a pattern of intensive, large scale, open sites outside the Central Rift. Excavations at Ngamuriak encountered possible hut floors, post holes, and both Ngamuriak and Olopilokunya contained ashy midden deposits (Robertshaw 1990). Internal site organization, evidence for structures, and disposal areas are not known for the Elmenteitan Central Rift rockshelter sites. The Remnant site is the only known Elmenteitan occurrence located in the high altitude of the Mau Escarpment. This region has been historically forested (but with open glades), and may have been more open between 3000-1000 years ago. Other open air sites like Gogo Falls and Wadh Lang'o near Lake Victoria, and the recent surveys in the Loita Hills support the likelihood are further demonstrating of Elmenteitan sites in southwestern Kenya (Marshall 1990; Robertshaw 1988, 1990, 1991). Ancient pastoralists

appear to have had similar settlement preferences as the recent pastoralists in the same ecotones. Open air sites were on well drained but low-angled slopes, within a short walk to water sources (Ambrose 1998, 2001; Gifford-Gonzalez 2015; Marshall et al. 2011).

Denser settlement in the southwestern highlands should not be surprising, as these plains fall within a zone of bi-modal rainfall patterns, permitting year-long dairying and thus overall increased pastoral productivity (Western and Dunne 1979). Indeed in the past even more ecological zones outside the southern Rift may have been more open than at present, further encouraging occupation of these areas (see Chritz et al. 2015).

Elmenteitan sites outside the rift changed assumptions about settlement patterns, previously based almost entirely on cave-sites and rockshelters, and suggested a possible hierarchy in Elmenteitan site size (Ambrose 1984a: 230; Robertshaw 1988: 63). This might suggest variation in site type, or differences in the size of social groups and livestock herds occupying these sites. The former idea is supported by comparison with ethnographic settlement strategies of the Maasai that include ceremonial villages (*manyatta*), homesteads (*enkang*), and temporary cattle camps (Mbae 1990; Spencer 2004). Conversely, the idea that site size was correlated with hierarchies would become important later as circumstantial evidence for social inequalities within the Elmenteitan group (see Robertshaw 1988).

2.4.4 Interactions with hunter-gatherers

Elmenteitan interactions with different hunter-gather groups appears to have played an important role in shaping the long term trajectory of this group. Whereas SPN groups appear to have had more direct affiliations with producers of the Eburran V traditions (as evidenced in ceramic styles), the Elmenteitan relationship with the Eburran may have involved more avoidance

or competition for resources (Ambrose 2001). There is less evidence of Elmenteitan material culture in Eburran deposits, and Elmenteitan layers overlie Eburran strata in many Central Rift Valley rockshelter sites. This is interesting, as the Eburran V groups had an intensive presence on Mt. Eburru and possessed a superior knowledge of its obsidian sources and forest resources, like medicinal plants, honey, or poisons. Some information sharing regarding these resources may have occurred, with the Eburran hunter-gatherers becoming forest-specialists as the Elmenteitan expanded through the western Central Rift by 2500 BP.

Elmenteitan interaction with the Kanyore groups is also largely speculative, but current evidence may point to overall more cooperative relationships. Elmenteitan layers do overlay those of the Kanyore at Gogo Falls and Wadh Lang'o (Lane 2004), but the Kanyore persists along the northern shores of Lake Victoria with no Elmenteitan presence. Chritz et al. (2015) proposes that the inclusion of large numbers of wild fauna at these sites reflect resource sharing and cooperation more than competition. In return for local ecological knowledge and wild foods, Kanyore fisher-foragers may have received some domestic stock- which possibly appear in Late Kanyore deposits (Prendergast 2009). Obsidian sourcing patterns support Elmenteitan-Kanyore interactions. The proportion and volume of obsidian from Mt. Eburru sources exploited by Elmenteitan groups increases in Kanyore sites after c. 2500 BP (Frahm et al. 2017).

There is evidence for complex and variable interactions between the Elmenteitan and hunter-gatherer groups in southern Kenya that differs from patterns noted for the SPN. It is interesting that these relationships involve Mt. Eburru and its obsidian sources- with Elmenteitan-Eburran competition around Mt. Eburru and Elmenteitan-Kanyore interactions best represented through the movement of obsidian from Mt. Eburru. The Elmenteitan Obsidian Quarry and the linked long-distance obsidian exchange system seems to have played an important role within

Elmenteitan strategies for hunter-gatherer interaction, and thus their spread into different environments.

2.4.5 Evidence for obsidian exchange

Patterns of raw material utilization present the most convincing evidence for exchange relationships connecting Elmenteitan groups. Between 80-90% of the total lithic artifacts at Elmenteitan sites can be sourced to a discrete outcrop of green obsidian on the northeast slope of Mt. Eburru (*Ol Doinyo Oporu*), at Elmenteitan Obsidian Quarry, first identified by Dr. Stanley Ambrose in 1980 (Merrick and Brown 1984:148; Merrick et al. 1988). Ongoing XRF and NAA sourcing projects across Kenya have produced an extensive catalog of obsidian sources, however the outcrops on, and immediately around Mt. Eburru, remain the only physical or geochemical match for the green obsidians that dominate Elmenteitan assemblages (Ambrose 2012; Brown et al. 2013).

Elmenteitan preference for green obsidian from the Elmenteitan Obsidian Quarry is maintained throughout the Lemek-Mara and Loita Hills, even at sites located over 250 km from Mt. Eburru, attesting to a level of provisioning within the Elmenteitan that exceeds simple down-the-line models (see Renfrew 1977). This pattern differs from what is known about the strategies of the technologically diverse foragers and SPN pastoralists who lived alongside Elmenteitan producing groups during the Pastoral Neolithic. Ambrose (2001) and Robertshaw (1990) proposed models for organized systems of obsidian exchange to explain the peculiar Elmenteitan obsidian use patterns. Recent XRF studies demonstrate that Kansyore fisher-foragers living near Lake Victoria were receiving small amounts of Eburru obsidian through interaction with nearby Elmenteitan groups (Frahm et al. 2017). The stark difference between the highly regular supply

within the Elmenteitan system and the sudden drop off in supply evident in exchange with non-Elmenteitan groups reinforces the cultural dimensions and corporate structure of this exchange as emphasized by Ambrose (2001). Access to, and use of, this obsidian had significant social implications for Elmenteitan producing groups.

As presented by Robertshaw (1990:296), the obsidian quarry could have been under the centralized control of particular lineages or groups. There are few lines of evidence for discerning these kinds of social institutions within the Elmenteitan, however technological strategies are a useful correlate for the kinds of social and economic strategies that would be involved in maintaining long distance exchange and differential access to resources.

Homogeneity in Elmenteitan material culture during this period must have been maintained by interactions among small groups distributed across the landscape. Involvement in regional exchange networks could provide the means for such interactions. Organized forms of lithic procurement would be necessary to supply stone to groups living across the Loita-Mara plains and in the Lake Victoria basin. Preferential use of the Elmenteitan Obsidian Quarry is a line of tangible evidence for Elmenteitan social connectivity. Understanding behavioral patterns at this important obsidian source is central to investigating how technology and raw material use were integrated into broader social systems. Proposals that Elmenteitan raw material preference was maintained by regional exchange or distribution systems have also been involved in debates over early herder socio-economic structures (see Ambrose 2001; Robertshaw 1988; Gifford-Gonzalez 1998b; Simons 2005). For example, Robertshaw (1990: 200) proposed that control of this resource by a local community could have fueled nascent inequalities, sparking one of the few discussions of early herder social organization. Understanding if the Elmenteitan Obsidian Quarry was centrally

controlled by a single group, or accessed more communally, is thus particularly important for evaluating current models.

Figure 2.8. 95% Probability distributions for calibrated radiocarbon dates from reported Elmenteitan sites (2 sigma). Calibrated with SHCal13 (Hogg et al. 2013), using OxCal v. 2.4 (Bronk-Ramsey 2013). Figure modified from Goldstein and Munyiri 2017.

2.5 Elmenteitan “Technological Organization”

2.5.1 Elmenteitan tool production

Tracing changes and divergences in Elmenteitan technologies within the quarry assemblages, and between sites across the landscape, is critical to understanding how obsidian cores were prepared and transported. Without this context, it is not possible to understand where variation exists, and which parameters of variation are meaningful.

Prepared core blade production characterizes most sub-Saharan pastoralist and forager lithic technologies throughout the mid-to-late Holocene, and Elmenteitan technologies are no exception. Elmenteitan producers relied on very large blades with low dorsal-ventral curvatures for many formal tools (Ambrose 1984a). Larger blades were used to manufacture formal endscrapers. Large blades were also employed as knives, occasionally even being uni-facially retouched.

Blades were also systematically segmented through lateral blows against an anvil (Ambrose 2001). There is often visible edge wear on the lateral margin produced during segmentation, indicating the segmented blades were often used as burin-like implements. This is supported by evidence of re-segmentation to refresh the working edge (C. Nelson 1980: 275). Larger blade segments frequently served as tabular bladelet cores for continued reduction. High frequencies of both the segmented blades themselves and the incidental “waste” products like derived segments or burinoids, reflect that blade segmentation was a common strategy for maximizing raw material utility at Elmenteitan sites.

Reduction of blade cores and large segmented blades continued until the production of bladelets under 3cm. These served as blanks for microlithic tools, most typically truncations, backed segments, and geometric segments (Ambrose 2002; C. Nelson 1980). Crescents are the

most common form of geometrics, probably being used for a variety of tasks, but there is evidence that the smaller Elmenteitan crescents were used as points in composite arrows (Goldstein and Shaffer 2016). Casually retouched and utilized flakes and segments are common as well, reflecting a concurrent element of un-patterned expedient tool use (Robertshaw 1990). Throughout the reduction sequence, blanks were segmented and retouched into a variety of typical “domestic” artifacts, including awls, percoirs, burins, and endcrappers.

At the very end of the reduction sequence is bipolar reduction. The most “expedient” of all reduction strategies, bipolar methods involve striking a core against an anvil, producing several small flakes of variable size and shape. It is typically seen as either a last-effort to extract utility from small fragments, or simply a more casual strategy in an absence of raw material curation stress (Duke and Pargeter 2014; Shott 1986). Formal artifacts may go through a series of “tool-transforms” (endscraper-to-notched tool is a common Elmenteitan transform), but the last phase of utilization is often bipolar reduction. Blade segments are also often subjected to bipolar reduction, producing rectangular bifacial artifacts called “*outil écaillés*” or “fabricators” in the regional literature (C. Nelson 1973), but may be better described as “splintered pieces” when they were used as cores (see Shott 1999). Extensive reduction of a splintered piece results in thin angular fragments called “*bâtonnettes*”. While often separated typologically, they reflect a single reduction sequence. This bipolar tool/core type is very rare in Eburran hunter-gatherer assemblages until after there is evidence of interaction with pastoralists (Ambrose 1998).

2.5.2 *Elmenteitan core technology*

Archaeologists have developed a robust framework for understanding lithic technological variability in the context of foragers that is well suited to the study of mobile herders (e.g. Bleed

1986; Kuhn 1991, Shea 2010; Seitsonen 2010; Surovell 2012). This body of research recognizes a range of strategies for core reduction, that contrast the *prepared* design elements commonly used within highly mobile strategies with the *expedient* design traits that characterize the technologies of more settled communities (Parry and Kelly 1987; Wallace and Shea 2006). Different approaches to core preparation and reduction along this spectrum reflect the range of economic preparations and raw material access of a particular group in time and space. For this reason, core morphology is one of the most useful archaeological correlates for mobility (Bretzke and Conard 2012; Clarkson et al. 2006; Parry and Kelly 1987).

Large cores are rarely found at Elmenteitan habitation sites, having been reduced until they were even too small for microlith production. Robertshaw (1988: 60) argued that such intensive use, coupled with high frequencies of bipolar cores, suggested of raw material scarcity, however fine-grained raw materials may be intensively reduced regardless of mobility (e.g. Shott 1986). Patterns of tool reduction at habitation sites do not indicate pressures for raw material conservation (Goldstein 2014). The conflicting nature of these signatures suggests at least the possibility for limited mobility in Elmenteitan lifeways. Furthermore, these technological differences have to be understood in the context of the specific mobility strategies and conditions for which tools and cores were being designed. If technological strategies were conditioned by the existence of a regional exchange network, we would better understand one piece of the much broader puzzle of Pastoral Neolithic socio-economic variability.

2.6 Conceptual framework for African pastoralism

2.6.1 Social and economic definitions of mobile pastoralism

Any analysis or interpretation of Pastoral Neolithic lithic technologies must first be grounded in an understanding of the social, economic, and environmental constraints of African pastoralism. I turn now to a discussion of these dimensions of recent African herding societies in order to develop relational analogies and generate informed expectations for the types of constraints and human responses we might reasonably expect in the past (*sensu* Wylie 1985). In the process, I aim to develop a vocabulary for describing the strategies and institutions of African herders, which may be unfamiliar to some readers.

Mobile pastoralists are typically defined as peoples whose livelihoods center on moving their domesticated livestock herds to pasture, as opposed to strategies of penning and foddering. (R. Dyson-Hudson and N. Dyson-Hudson, 1980). In Africa, the animals featured in pastoralist lifeways include cattle, sheep, goats, and camels. Donkeys also play an important role as pack animals, but are rarely consumed (Marshall and Weissbrod 2007). In arid environments like those in much of eastern Africa, contemporary pastoralists, by necessity, incorporate other food resources into their subsistence economy through hunting, fishing, cultivation, and trade (Dahl and Hjort, 1976; McCabe, 1990; McCabe et al., 1994). Nevertheless, the dietary needs of the herds are privileged above the location and timing of all other activities, and movement of herds to access grazing lands structures residential and logistical mobility (Gifford-Gonzalez 2005: 88; McCabe 1994).

Mobile pastoralists relocate settlements as needed to access pastures. Locations of good grazing land may change between disparate locations year-to-year due to environmental heterogeneity and the unpredictable rainfall patterns of eastern Africa (Behnke and Scoones

1992). Herders move around a landscape in family units, sharing the labor of herding and herd defence from predators and raids. Mobility may be organized to access resources unevenly distributed in space and time, but is also a response to shifting social and political conditions (Dahl and Hjort 1976; McCabe 1994). These strategies must remain flexible so that people can effectively respond to fluctuations in climate and rainfall that occur on the seasonal, annual, inter-annual, and decadal scales (Dahl and Hjort 1976; Verschuren 2004). Movements of African herders, therefore, differ from strategies of vertical or seasonal transhumance that are common pastoralist strategies in other parts of the world. Pastoralists discussed within this dissertation are defined by these parameters: Peoples who both rely primarily, but not exclusively, on livestock, and also structure their mobile strategies to accommodate optimal herd management. Understanding these fundamental aspect of mobility is necessary to engage with the subsistence and technological data that dominates the East African archaeological record.

Central to understanding African pastoralism as a unique phenomenon in the global context of food production, but harder to detect archaeologically, are its deeply rooted ideological underpinnings. Recent African herders often see themselves as “people of cattle”, emphasizing that ownership of livestock is a central component of both individual, and group identity (Evans-Pritchard 1940; Homewood 2008; Spear and Waller 1993). These identities structure the way herders interact with foragers, which can manifest as episodes of subjugation, formation of client-patron relationships, or mutualistic relationships based on specialized exchange (Brenzinger 1997: 279; Grillo 2015; Turton 1979). It is also because of these emic conceptions that Africanist researchers do not typically sub-categorize pastoralist economies that include of cultivation and/or wild food procurement. Economic flexibility is often necessary in arid environments, and participation in subsistence systems outside of strict herding is constantly fluctuating, and more

importantly, does not affect how herders see themselves (R. Dyson-Hudson and N. Dyson-Hudson 1980:47; Homewood 2008; Spear and Waller 1993). Identifying pastoralist emic perceptions in the past has proven challenging. Rock art provides a window into the material symbol systems of ancient herders, and ritualized cattle and/or cattle bucrania burials suggest ancient herders also valued livestock beyond their economic value (di Lernia et al. 2013). Both rock art and cattle burials are rare in East Africa, and difficult to date.

Present day and historical patterns of movement in the region are relevant (*sensu* Wylie 1985) for interpreting concepts of pastoralist mobility and ancient pastoralist systems. Herding, past and present, is structured by the same basic ecological and environmental constraints, namely rainfall, soils, and landforms. People make choices, but only within a specific range of options. Mobility strategies, economic diversification, and social institutions that are commonly observed today likely existed in forms different in degree, but not in kind, to those that existed in the past. In order to provide expectations for the archaeological record in the following sections, I will now discuss the fundamental forces that structure African pastoralism, as documented ethno-historically.

2.6.2 Pastoral ecology and mobility

Mobility is a central organizing force in African pastoralist lifeways. Herders develop complex systems of residential movements of family and kin, and logistical movements of friend groups and individuals, moved to graze livestock, access resources, and engage in informal exchange. In eastern Africa where this dissertation is focused, movement typically relates to subsistence and political considerations rather than trade. There are few historic examples of groups who specialized in commodity transfers, but these tend to be hunter-gatherers like the

Waata Oromo (*Waliangulu*) of Tsavo, who specialized in elephant hunting to supply ivory to the formal trade networks on the Swahili coast (Kassam and Bashuna 2004). Historic trade expeditions for livestock and slaves from coastal regions also reached into the Lake Turkana and Mursiland region of southern Ethiopia (Glassman 1995). These examples are only within the last two centuries, and there is little evidence of specialized traders before that time.

Much of the variation in historic African pastoral mobility is due to specific ecological conditions, with high residential mobility being more common when rainfall is less predictable (Behnke 1995). This dissertation focuses on southern Kenya, in which the human ecology of pastoralism is particularly well documented. The modern climatic regime of bi-modal rainfall in southwestern Kenya was established by 3000 BP, but has fluctuated significantly throughout both prehistory and recent history (Ambrose 2001; Ashley et al. 2011; Garcin et al. 2010).

Seasonal shifts in the Inter-Tropical Convergence Zone bring monsoonal rains to East Africa twice a year, producing both a long (March-May) and short (October-November) rain. Savanna zones in southern Kenya receive roughly 600-900 mm of annual rainfall as a result. High rainfall in this savanna zone allows an increased rate of calving, and thus overall pastoral productivity (Herlocker 2000). In areas with bi-modal annual rainfall, this allows herds to produce milk throughout the year (Marshall 1990; Western and Dunne 1979). As pastoralists are keenly aware, however, the monsoonal rains are unpredictable in space and time, and are likely to fail at least once a decade (Western 1982). Pastoral strategies in these environments are predicated on taking advantage of high rainfall years to build up a large enough herd to survive inevitable drought episodes where losses are substantial (Dhal and Hjort 1976; McCabe 1990).

Ethnographically, a wide variety of camp size and intra-site organization has existed in eastern Africa. Environmental conditions are the primary factor structuring duration and

organization of homesteads (Shahack-Gross et al. 2004). Wetter conditions are more likely to encourage larger and longer term settlements. In the grasslands of the Loita-Mara that receive the highest average rainfall rates, Maasai herders easily accomplish this with relatively low mobility when conditions. Basecamps may persist as long as ten years, and herding circuits for livestock may range from just 2-10 km per day (Homewood 2008; Marshall 1986; Spencer 1965; Western and Dunne 1979). Major aggregations like age-grade ceremonies require the construction of very large multi-family habitations, and so are often delayed until periods of particularly high rainfall and/or social stability (Mbae 1990). Residential relocations are more frequent during dry spells, with families moving up to 100 km or relocating herds between complementary ecological zones up to 200 km away (Western and Dunne 1979; McCabe 1999: 115). However, communities in the past may have aggregated to share resources during dry periods, as has been documented for the Turkana, Rendille, and Karamojong of arid northern Kenya (McCabe 2004).

African pastoralists also face other ecological and social threats that structure their mobility. Some of these challenges stem from bush expansion during wet periods that increases the likelihood of tsetse born trypanosomiasis and other tropical human and livestock diseases (Gifford-Gonzalez 2000). Herders actively manage, or avoid, bush-dominated ecologies, adding another layer of complexity into the organization of group mobility. Finally, the threat of raiding and conflict is a particularly profound social threat to pastoral lifeways that is often a cause, and effect, of residential mobility. On an occupied landscape, regular patterns of mobility bring groups into competition, and during droughts raiding is a common mechanism for communities to recover livestock (McCabe 2004). Responses to the threat of raiding is also accomplished through mobility.

2.6.3 Defining “networks”: exchange and alliance

African herders develop social institutions to mitigate risk in environments where resources are unevenly distributed through space and time. Ubiquity and prominence of these structures reflects how important they are to recent pastoralist lifeways, and provide the necessary framework to evaluate whether or not similar systems, in different forms, existed in the past.

Access to distant pastures and reserve grazing, requires the formulation and maintenance of strong social bonds across communities (Homewood 2008; Marshall and Weissbrod 2011; Spear 1993: 126). Stock-associations or trade-friendships are common social contracts that form the basis for alliance between individuals. Herders lend stock to trusted associates to disperse their herds and reduce the risk that a single raid, flood, drought, or other catastrophe will leave them destitute. People also lend stock to help associates recover from misfortune, with the expectation that all descendants from the borrowed stock belong to the lender and the lendee will owe some additional small-stock as “interest” to be paid over time (Schneider 1979; see also description in Robbins 2006: 142). Partnerships and associations can be based around shared descent, lineage, or clan, however they often develop incidentally between previously unaffiliated individuals. The latter relationship is referred to as a “stock-friend” or “stock-associate”.

Livestock gift-giving and exchange are vital means of risk mitigation, allowing families to recuperate herds after droughts or livestock epidemics (Dombrowski 1993:28; Aktipis et al. 2011). First, exchange provides disparate communities with access to key resources that may not be ideally located within the range of herd-based mobility strategies. Secondly, relationships like stock-associations become the basis for communal insurance under the expectations that ‘if I help you during your time of hardship, you will help me during mine’ (Schneider 1979: 198-199). Families expect to lose 80% of their stock during droughts and by establishing these relationships,

risk is successfully dispersed across many allied communities across different micro-environmental zones (Dahl and Hjort 1976). Historically, these relationships were also invoked when soliciting help for defense against raids or efforts to forcibly acquire new grazing lands for other groups (McCabe 2004; Turton 1979; Spencer 1973).

More expansive inter-social connections are achieved through shared participation in age-grade institutions (Homewood 2008; Salzmann 1999). Membership in an age-grade, stock association, or similar institutions connects individuals to each other, but also to a broader “pool of relations” (Geertz 1961: 25) from which an individual can draw support or exercise claims. By participating, herders acknowledge social obligations to help people beyond their own kin, and whom they may not personally know, but also that those obligations would be reciprocated (Gulliver 1971: 18). On one level, these relations are continuously enforced through the lending of livestock or trade, but also provide the structure for instances when ephemeral collective action is required. Obligations may, for example, be invoked when a community is externally threatened by raiding, or internally when an individual has violated social rules or when ritual action is required. Involvement will vary highly from individual to individual based on personal charisma of the actors, proximity to allied groups in need, age, social authority, personal skill-set, etc. As a result, each individual is involved in multiple partially overlapping relationships that fluctuate through time and space, but are nonetheless bound by a certain set of shared cultural principles.

This system is what Gulliver (1971), in his ethnographic work on the Ndeneuli of Tanzania, explicitly defines as “network” (Figure 2.8). Following this definition, webs of relations and reciprocity have been recognized from ethnographic research among a broad range of East African herders (Berntsen 1979; Fratkin and Galvin 1994; Galaty 1982; Galvin 2009; Schneider 1979; Spencer 1973, 2004). While there are other, theoretical, definitions for networks and alliances, I

will preference the practical definition born from observation of real systems in action. Therefore I follow Gulliver (1971) in using “network” to refer to this system of social relationships and obligations across disparate communities, generated through shared adherence to an ethnic identity— however constructed.

“Exchange networks” refers to the web of individual episodes of exchange governed by underlying social relationships (Figure 2.9). Each episode may appear informal and small-scale; however, when viewed as nested levels of interaction at a landscape level, they form large regional exchange systems (Bernsten 1976; Bollig 2000; Frachetti 2014; Lee 1972; Robertson 1976; Salzman 1971; Sobania 1991). Exchange may be a means of maintaining a network or phenomenon that arises out of, and is structured by, existing networks. Often it is both.

If pastoralists measure wealth in livestock, then this practice, in conjunction with bride price practices and animal slaughter at major ceremonies, help make sure there is not too great an accumulation of wealth in any one place and time (but see Borgerhoff Mulder et al. 2010). Livestock may be the most economically important resource moving through networks, but it is far from the only one. African pastoralists move a wide variety of subsistence goods and material culture between themselves and other groups including grains, honey (and importantly honey wine), sugar, medicines and poisons, beads and personal adornments (important for rituals and coming-of-age ceremonies), and iron tools. In the Sahara where populations are particularly dispersed, some herding groups become trade-specialists to facilitate exchange (Nicolaisen 1963). In eastern Africa today some individuals may take it upon themselves to become “traders” for periods of time (see account in Robbins 2006: 190-202). Individuals with a more advantageous position within an exchange network, or who have achieved social status as a prophet (*laibon*) may

circumvent the normal social-leveling mechanisms, at least to some degree (Borgerhoff-Mulder et al. 2010).

Maintaining access to fixed, and distant, raw materials and other resources while group mobility is so tied to the needs of the herds requires the deployment of regional exchange networks, and social institutions to maintain them. How mobile pastoralists organize their economic safety nets often depends on the agency of individuals, as well as clan dynamics (McCabe 2004).

2.6.4 Social structures of exchange

Long-distance exchange is typically carried out through highly socialized institutions that are deeply embedded within pastoralist cultures. The structures existing in the ethno-historic and ethnographic present provide a template for generating expectations and testable hypotheses for the organization of exchange in the archaeological past.

Exchange is often structured along gendered parameters. Women are typically responsible for localized movement of goods between nearby families and communities. Their domain includes ceramics, dairy products, plant foods, medicines, textiles, and beadwork (see Grillo 2016). It was historically women in herder societies who most often traded with neighboring hunter-gatherers and agriculturalists for subsistence products and personal adornment (Kratz et al. 2000). So important is this exchange to the long term sustainability of pastoralist lifeways, that in some cases it was forbidden among the Maasai to harass or attack women engaged in trade even during the most fierce and violent episodes of inter-group conflict (Leakey 1977).

Figure 2.9. “Elementary network model” demonstrating how personal relationships (a) build into institutional relationships (b), which become integrated into increasingly complex connective networks (c). After Gulliver (1971: 22).

Men are typically charged with long-distance affairs and business that concerns the exchange of cattle and other livestock, or wild game. For example, men will be responsible for acquiring projectile tip poisons from hunter-gatherers, and trading with smiths and other specialist craftspeople. Ritual paraphernalia and the materiality of prophecy are also seen as the domain of men. Pastoralists, especially Nilotic speaking groups, in eastern Africa commonly employ age-grade systems that separate young men from their family units and livestock management responsibilities to serve as warriors, or for other specialized purposes for several years (Spencer 2004; Sperling 1987).

Figure 2.10. Web of cattle loans between Turu households within a single month in 1960. From Schneider (1979: 199).

During this time, young men are charged with herding and protecting cattle, searching for new pasture, and raiding livestock from enemies. Often they will live in specialized “garrison” like *manyatta* or will live the bush during these years, receiving gifts of meat from the dispersed communities they aid as they travel around the landscape. Their travels are typically expansive across a region, cross-cutting boundaries between sections and social groups. In recent decades the role of long distance travel among young male age-grades has shifted away from raiding or moving cattle, and toward cattle exchange and developing more expansive stock-partnerships (Amin et al. 1987). Friendships formed during through these logistically oriented activities in ethnographic and ethnohistoric contexts are importance in reifying social alliances and exchange networks in

subsequent generations (Bernsten 1976; Bollig 2000; Fosner and Kertzer 1978; Lee 1972; Nicolaisen 1963; Robertson 1976; Salzman 1971; Sobania 1991).

In many ways, exchange networks and social institutions of alliance are deeply intertwined within eastern African pastoralist societies. These systems expand risk-mitigation networks across a wide geographic area and are more expansive than networks limited to descent groups. Alliances can also be leveraged proactively to facilitate the spread of allied herding communities into new regions. The best example for this is the 'Ateker confederation' consisting of the Turkana, Karamajong, and other groups, wherein military alliances were formed to facilitate their forced spread into northern Kenya (Lamphear 1988). Interpersonal exchange systems were also critical in maintaining the alliances that fueled the expansion and stability of the Maasai in southern Kenya and northern Tanzania (Spear and Waller 1993). While these systems are well documented ethnohistorically, there has been little detailed attention to the formation of pastoralist exchange or alliance 'networks' archaeologically.

2.6.5 Archaeological perspectives on pastoralist exchange

The perspectives derived from ethnographic and previous archaeological work have been employed to generate preliminary models for exchange amongst early herders in eastern Africa, some of which form the basis for this archaeological project.

It is no surprise that the role of mobility is stressed in archaeological research on African pastoralists. Studies have addressed pastoral mobility conceptually, through site distributions, stratigraphic depth, and internal spatial data (Brandt 1987; Gifford-Gonzalez 2005; Lane et al. 2004; Marshall 1986; Marshall and Hildebrand 2009; Marshall et al. 2011; Smith 1983), with isotopic studies (Balasse et al. 2002; Price et al. 1994; Tafuri et al. 2006), and ethno-archaeological

projects designed to relate site formation processes and materiality to mobility (Biagetti 2014; Shahack-Gross et al. 2003; Weissbrod 2010). Ceramic and lithic material culture studies have also been re-assessed for their value in addressing issues of herder mobility (Ambrose 2002; Goldstein 2014; Grillo 2014, 2015).

Archaeologists acknowledge that exchange was as important to prehistoric East African pastoralists as it is for ethno-historic and modern groups (Ambrose 1988; Gifford Gonzalez 2000; Marshall and Hildebrand 2002; Smith 1992). Although these logistical forms of mobility have been more difficult to identify and dissect, raw materials for stone tool production that were transferred between communities in the ancient past offer robust opportunities for beginning these investigations. Obsidian, the preferred raw material of many herding societies throughout eastern Africa, is a prime example.

Considering the Elmenteitan pattern, both Ambrose (2001) and Robertshaw (1990) postulated the existence of a regional exchange or distribution system. Robertshaw went further to propose that such a network was embedded in pastoralist social institutions and possibly tied to social inequalities (Robertshaw 1990: 296). Preferential use of the Elmenteitan Obsidian Quarry is a critical line of tangible evidence for Elmenteitan social connectivity. Understanding behavioral patterns at this important obsidian source are central to interpreting variation in Elmenteitan lithic technological patterns and understanding how technology and raw material use were integrated into broader social systems.

The proposition that the Elmenteitan raw material pattern is evident of a regional exchange web has also been at the center of debates over the socio-economic structure of the Elmenteitan (Ambrose 2001; Robertshaw 1988; Gifford-Gonzalez 1998b; Simons 2005). For example, Robertshaw (1990: 200) proposed that control of this resource by a local community could have

fueled nascent inequalities, sparking one of the few discussions of early herder social organization. Understanding if the Elmenteitan Obsidian Quarry was centrally controlled by a single group, or accessed more communally, is thus particularly important for evaluating current models. Such a pattern also has implications for how the remainder of the Elmenteitan exchange network would have functioned. These discussions represent attempts to study a prehistoric version of pastoralist exchange systems and serve as both the motivation and the foundation for this dissertation project.

2.7 Summary

Lifeways based on mobile pastoralism in Africa followed novel trajectories against the backdrop of dynamic demographic and climatic change. For many pastoralist societies, ownership of livestock is not just an aspect of subsistence but a central structuring dimension of social identity. Motivated to provide economic – and cultural- security, pastoralists in the unpredictable and drought prone environments of eastern Africa deploy complex alliance “networks” (*sensu* Gulliver 1971) as a means of dispersing risk and ensuring economic security.

Through participation in these systems, widely dispersed herding communities are guaranteed a degree of assistance should they face external or internal stress, and the rights to access grazing lands and other resources as rainfall patterns shift on yearly, decadal, and century-scale cycles. While alliances do not require personal connection with all communities, individuals and families must maintain affiliation with the *system*– often through involvement in age-grades or other social institutions and trade/exchange relationships. The overlapping webs of affiliation that each individual or family possess build the alliance network. Ethno-historically, these alliances have been vital in sustaining herders in eastern African environments, and were actively invoked in the spread of pastoral groups into new regions.

Despite the importance of these systems in the ethno-historic present, there has been little discussion of when or why such alliances developed in the archaeological past. Identifying such systems is difficult. Long-distance exchange and shared material traditions that differ from observed patterns among foragers are the most archaeologically visible lines of evidence to begin to identify and trace these systems. From this perspective, there is limited evidence for the formation of alliances or networks among early African herders until they arrive in the Great Rift Valley around 5000 years ago. Here, the clear distribution of obsidian around Lake Turkana, appearance of a uniform technological strategy, and investment in a monumental mortuary tradition all suggest a form of social “alliance” was taking hold.

It is not until after 3500 BP that a strong signature for specialized pastoralism appears in southern Kenya. The two major early herding traditions, the Savanna Pastoral Neolithic and the Elmenteitan, both appear to have been engaged in long distance exchange of obsidian co-occurring with discrete material traditions and settlement patterns (Ambrose 2001; Gifford Gonzalez 2015). Of these, the Elmenteitan system appears far more cohesive, involving the distribution of obsidian to communities spread across southwestern Kenya. Furthermore, Elmenteitan groups demonstrate an overwhelming preference for obsidian from a single, discrete, obsidian source on the upper slopes of Mount Eburru.

Investigating the Elmenteitan pattern and how it functioned is the most promising opportunity for contributing archaeological perspectives on the forms of social alliance building that may have been important in sustaining the spread of ancient pastoralism. The research of Robertshaw (1988), Ambrose (2001), and Gifford-Gonzalez (2000), has presented several hypotheses on formation and social role of the Elmenteitan obsidian exchange system that are specifically investigated in this dissertation.

Chapter 3

APPROACHES TO THE STUDY: LITHIC TECHNOLOGY, LEARNING, AND EXCHANGE

3.1 Technological Organization

In this chapter I discuss a number of methodological approaches necessary for developing a holistic study of lithic operational sequences and lithic technological organization (TO), beginning with archaeology of sources and quarry sites, and tracing the movement of lithic material through archaeologies of exchange. I employ archaeologies of identity and social boundaries that structure exchange, and archaeologies of learning relevant for interpreting lithic signatures, and discussing the transmission of lithic knowledge associated with quarry use. Only by combining these different lines of thinking about technological systems, and the forces that affect them, is it possible to address questions regarding early pastoralist social and economic strategies during the spread of food production. I lay out here the framework of technological organization in lithic studies which forms the basis for my work.

As elaborated by Margaret Nelson, technological organization focuses on the strategies for “making, using, transporting, and discarding lithic tools and the materials needed for their manufacture...” (1991: 57). Lithic technologies are, after all, a means of problem solving, in Binfordian terms, a means of exosomatic adaptation to environmental conditions (Binford 1973, 1977, 1979; Bleed 1986; Kelly 1988; Torrence 1984). Specific technological systems will be better suited to some environmental circumstances than to others, although human agency plays a role in shaping lithic strategies (Bleed and Bleed 1987: 189). Choices within these technological regimes are visible in design, reduction strategy, and raw material use. Given a set of environmental parameters, stone tool using cultures develop strategies structured by a cost-benefit

calculus weighing various economic and social variables (Andrefsky 1991, 2004; Bamforth 1986; Holdaway et al. 2010; Shott 1986, 1989). This framework was developed explicitly in reference to lithic technologies, and will be used here exclusively to discuss stone tool making systems

The concept of technological organization within lithic studies was developed within the context of hunter-gatherer research, particularly in North American and Pleistocene Europe. This concept can, however, be easily adapted to the situation of African pastoralism. Mobility is a central component of TO approaches. Just like foragers, ancient pastoralists had to develop strategies to acquire stone, transport it from the source to different sites, manage stone supply, and curate tools and cores. Pastoralists simply structure mobility around a different set of parameters than do hunter-gatherers, and these decisions will be reflected in the lithic record. Different degrees and forms of mobility strategies shape raw material access and management, and so will produce identifiably different lithic signatures that can be quantitatively evaluated by archeologists (Andrefsky 2010; Arnold 1987; Nelson 1991).

Trade and exchange, as social strategies, do not exist outside the realm of lithic technological organization. They are often central components to it, and social systems are explicitly connected to risk-reduction within technological organization (Andrefsky 2010; M. Nelson 1991). Following Wobst (1977), variation within lithic technologies is intertwined with, and reflective of, social identities. Hunter-gatherers tend to acquire material through direct or embedded strategies, and acquisition through exchange is generally limited and down-the-line (see Binford 1979; Gould and Saggers 1985). Evidence for sustained long-distance raw material provisioning of obsidian from specific sources among early herders in southern Kenyan can be used to develop new models for connecting lithic exchange, lithic technological organization, and socio-cultural systems.

3.1.1 Curation and expediency

Lithic technologies vary primarily along axes of “curation” and “expediency” (McCall 2012; M. Nelson 1991; Shott 1986). This is to say, these approaches seek to quantify the degree to which toolkit design reflects preparation and anticipation for particular challenges (i.e. curation) versus *ad-hoc* solutions to immediate needs (i.e. expedience) (Andrefsky 2010; Bamforth 1986). Decisions on the balance of curated and expedient lithic technologies are made based on discrepancies between access to, and supply of stone, and expectations about the types of tools needed for future tasks (Binford 1979; Keeley 1982; McCall 2012; Torrence 1984).

As a pastoralist, one such logistical problem would have been the need for high quality stone for daily tasks from sources far away from good grazing lands and pastoralist settlements. Pastoralists also structure activities such as large ceremonial aggregations, movement for water or salt, and herding circuits differently during wet and dry seasons. People might need stone during periods of times of the year when supply is impeded by any number of social or environmental conditions like heavy rains, droughts, raiding, or livestock disease outbreaks. Assuming the need for obsidian is not *entirely* social, its preferential use suggests a need for reliable and predictable flaking mechanics that high-quality volcanic glass provides. This is consistent with a more curated strategy wherein people are planning for future stresses that might limit their ability to access high quality raw material. However, if obsidian supply becomes highly dependable, as it might through a formalized exchange system, then people may have the liberty to engage in more expedient technological strategies. Evidence for this would include larger platform area to flake area ratios, higher flake-to-blade ratios, or more variability in flaking sequences, less formal core designs, less evidence of resharpening, more microwear and utilization edge damage and more transformed tools, and more expedient bipolar pieces.

We must also consider the forms of logistical mobility unique to herding societies, i.e. herding circuits. Individuals taking herds out for a day, week, or month, will be using stone differently, and under different pressures, than people remaining at habitations. When individuals return to the site, the remains of their toolkits may be deposited at habitations, creating mixed signals in terms of curation vs. expediency. Time is also an important dimension of variability within a system based on exchange rather than opportunistic access through residential mobility. If sites are occupied for long periods of time, then the lithic assemblage may reflect both periods of abundant and strained access to obsidian, and this could create a palimpsest of lithic technological behaviors that complicate archaeological interpretation (see Goldstein 2014).

Even so, distance from source will be the most important variable. Groups with obsidian sources within their normal home range might be expected to have expedient tool use. For sites further from the source, the important variable is rate of replenishment of supply to members of a settlement. If seasonal stock camps are provisioned with raw material from their home communities, then their stock camps might show more curation, including more intensive retouch and/or utilization, more tool transforms, and more evidence of tool or blade resharpening. A lithic technological organization study of pastoral economies must incorporate these realities into analytical and interpretive structures.

How people solved problems related to obsidian access and mobility form the foundation for their technological organization. Basic assumptions about risk-reduction are built into these models (Andrefsky 2012; Bamforth and Bleed 1997; Torrence 1984). In particular, that efficiency (real or perceived) is driving technological strategies, and that people will privilege subsistence needs in making decisions about raw material acquisition (M. Nelson 1991). Models so far developed generally assume that people are mobile, and that mobility strategies will be the primary

force structuring lithic production strategies (Andrefsky 1994a; Blades 1999; Kuhn 1991, 2014; Parry and Kelly 1987; Surovell 2009). Ambrose (2002) and Slater (2016) also stress that how people plan for mobility is structured by their shared memory or knowledge relating to the tasks that may be required in different areas. Specific toolkits may be brought if people can anticipate a narrow range of needs, or more generalized and versatile toolkits may be brought if people expect a wide range of tool-use opportunities, or have little previous knowledge of a location.

In order to reconstruct Elmenteitan lithic organization, there are several issues that I must address through lithic analysis: How did Elmenteitan herders manage their supply of obsidian? To what degree was lithic acquisition embedded within formal curated networks or mobility strategies? Does the structure of lithic organization at different Elmenteitan sites reflect different strategies based on environmental, climatic, or cultural conditions? Are they affected by variation in activities at different types of sites? These questions can be answered through lithic technological analysis on a site-by-site basis, assessing the rates of curation on retouched tools and studying the composition of the debitage assemblages.

Alternatively, the system itself can be studied through an approach focused on core technology. I argue that given the paucity of curated tools like scrapers or bifaces within Elmenteitan assemblages, and the relatively small number of habitation sites with extensive excavations, a concentration on cores design and reduction is best suited to understanding technological organization of early herders in southern Kenya. However, cores too are very rare in anything other than expended forms at most PN sites. Unmodified blades of various sizes are more abundant. Each blade preserves a small snap-shot of the morphology and design of the parent core at the moment it was removed. Therefore, I will use the larger blade assemblages as a proxy

for core design and reduction strategies in assessing the organization of Elmenteitan lithic technology.

3.1.2 Core Technology

This framework posits that lithic reduction strategies were designed to ensure that people had enough stone on hand to fulfill the social and economic objectives that would arise until more stone could be procured (M. Nelson 1991; Kuhn 1991). The spectrum of core morphology can be envisioned with highly curated “formal” core technologies on one end, and more opportunistic core technologies on the other. Formal cores require more preparation, and are designed to produce flakes that are of consistent size and shape. Expedient cores require little preparation, and provide little control over flake morphology. Formal technologies are typically associated with more mobile strategies, and expedient strategies are often a result of stock-piling at more permanent habitations, or of abundant raw material supply at quarry sites. Theoretically, formal cores should exhibit higher raw material utility, however experimental replication have shown that this is not always the case (Carr and Bradbury 2001; Jennings et al. 2010). Any stone tool using group is likely to produce a range of cores falling into both categories, allowing for a range of options than can vary through space and time. Assessing decisions about core management and design is relevant for assessing degree of mobility and raw material supply, and on a regional scale can reveal differences in exploitation strategies across environments.

Cores themselves are not tools or final products, but are the means of producing blanks. Evaluating and quantifying the organization of core technologies first requires consideration of core design as it pertains to the morphology and variation in blanks that can be produced through lithic reduction. Several axes of design variation have been proposed by researchers, but generally

include versatility, flexibility, utility/maintainability (see M. Nelson 1991:70-71). Flexibility is defined in terms of the range of blanks that can be produced from a given core design, with versatility relating to the ease of modification that would result in a change to flexibility (Shott 1986, 1989: 19).

Maintainability, may focus more specifically on the raw material cost (i.e. the utility cost) of modifying the core through the reduction process to preserve elements of blank morphology. *Tablette de ravivage*, platform rejuvenations, and other core trimming elements are examples of such modifications that incur a very real raw material cost (Clark 1987; Gamble 1986; Eren and Prendergast 2008). Preparing a core such that there is consistent blank morphology (e.g. highly curved, flat, wide, narrow) is otherwise called “reliability”.

All else being equal, less mobile groups often choose to stockpile large quantities of stone when possible, and reduce nodules expediently when needs arise (Parry and Kelly 1987; Wallace and Shea 2006). More mobile societies instead stress maximizing the use-life and utility of their raw material supply through the production of formal cores, owing to less dependable access. Production of highly specialized morphologies can also be a sign that tool forms are serving as markers or regional or social identities (Morrow 1987). Furthermore, standardized patterns of blade production can be associated with tight control of raw materials by elites, or control of technical knowledge by specialists, another reason it is important to consider patterns of lithic learning (see sections 3.5-3.6) (Roux et al. 1995; Stout 2002; Summerhayes 2004).

The final dimension of core treatment relevant to technological organization studies is raw material access. Not all societies, and certainly not East African herders, were able to embed lithic procurement easily into seasonal rounds. In such cases alternative, often social, strategies are needed to maintain access to stone. Bamforth (1986) argues that, when it is necessary to go out of

the way to acquire stone, or when stone quarries are not present within subsistence orbits (i.e. embedded procurement is not possible), source-to-site transportation incurs a significant cost of time and energy. When a pattern of high-cost lithic acquisition is identified archaeology, it is important to determine why people went through the extra effort.

Sourcing of obsidian in eastern Africa suggests that many Pastoral Neolithic communities like the Elmenteitan chose to address the problem of acquiring high quality raw material from distant sources by investing in regional exchange (see Ambrose 2012). Exchange mechanisms involved, but were certainly not limited to, the movement of high quality obsidians to fuel stone tool industries primarily organized around blade reduction. Beyond a few technical differences between pastoral assemblage groups, there has been little discussion of pastoralist technological organization in eastern Africa (but see Ambrose 2001). Although we can make broad statements about particular trends within the Elmenteitan (see previous section), there is no firm understanding of how much variability exists across sites, what structures that variability, or what these differences in TO mean for understanding mobility, economy, or social structure.

I argue that in order to understand Pastoral Neolithic and specifically Elmenteitan technological organization, it is most logical to focus attention on ancient lithic quarries and workshops. Quarry sites were centers for both core preparation where design is imposed, and the starting point for the exchange systems that transported cores to communities spread across southern Kenya. Quarry archaeology is embedded within, and compliments, the TO approach by offering a powerful set of tools for understanding both the economic and social dimensions of technological systems.

3.2 Quarry Archaeology

Mines and quarries where raw stone is *extracted* can be spatially disparate from the workshops where raw stone is *processed*, or both sets of activities can occur in the same location. The latter condition applies to the Elmenteitan Obsidian Quarry, and so for the sake of clarity I will use the term “quarry” only.

Lithic quarries are the origin points for technological strategies on a landscape level. Any thorough study of lithic technological organization must consider how raw material sources were accessed and exploited by prehistoric groups, and how preparation of cores at the quarries structures broader morphological variation. The extraction, preparation, and transportation of lithic raw material are fundamental components of prehistoric technological systems and are embedded within social institutions, and webs of social interaction, across the landscape (McCoy et al. 2011; Messenio and Barros 2015). Archaeological projects focusing on lithic quarries have generated a great deal of insight into the nature of exchange systems and economic strategies in numerous contexts around the world (Bettinger 1982; Bryon 1950; Ericson 1981; Gopher and Barkai 2011; McCoy et al. 2011; Tripeceovich and Mackay 2011)

3.2.1 *Interpreting lithic patterns at quarry sites*

Lithic extraction and processing sites formed central nodes in the prehistoric exchange systems that ensured long term economic resilience for stone tool using communities. Activities at quarry sites often produced dense deposits of lithic debris, providing a diachronic record for how societies structured broader technological strategies (Affolter 2002; Andrefsky 1994; Beck et al. 2002; Binford 1979; Messineo and Barros 2015; Shott 2015; Torrence 1986; Tripeceovich and Contreras 2011). Archaeological investigations of quarries use these rich datasets to contextualize

patterns observed at sites across a landscape in order to understand how sites were connected through networks of exchange and interaction (Ericson 1984; Taçon 2004; Topping and Lynott 2005). As important central places, quarries and workshops facilitated interaction among mobile societies, who actively used these locations to organize trade partnerships and maintain political alliances (Bettinger 1982: 115; Bloxom 2011: 149; Purdy 1984).

Abandoned cores and preparation debris are useful in reconstructing the strategies for core production. Different patterns of core production at a quarry as seen by archaeologists are a proxy for the nature of social interactions at a landscape level. People in different environmental conditions, with different mobility strategies and economic practices are expected to modify their lithic technologies according to these specific needs. At a quarry site supplying communities across many such niches, the patterns of core preparation reflects the social distance between those preparing cores, and those who will ultimately be receiving them across the landscape (Ericson 1981, 1984; Messineo and Barros 2011). It is thus possible to differentiate between different forms of economic access.

Direct or embedded procurement occurs when individuals travel to quarry site either on special purpose trips or as they come into contact with sources within the course of normal season mobility (Binford 1979; Gould and Saggers 1985). This does not manifest itself in the same way as either down the line exchange (McCoy et al. 2011; Renfrew 1977) or more formal trade (Gamble 1999), wherein obsidian could move through a number of different agents, communities, or regions.

Formal trade is more likely if a single group controls aspects of obsidian quarrying (e.g. Dalton 1969; Spence 1982: 188-9). In this case, one group of producers would be making decisions about core designs, which may differ from the requirements of distant groups receiving material,

who many have divergent mobility strategies and economic adaptations from the producers at the quarry. As a result of raw material acquisition and distribution becoming a specialized activity, it is possible that trimmed nodules will be the only core type exported, so that recipients can tailor them to their own needs without wasteful morphological adjustments (Weisler 2011: 305). Hierarchical resource control should be visible in the spatially centralization of quarrying and core workshop areas close to the source, with evidence of more consistent and systematic extraction and core production sequences (Ammeran and Andrefsky 1982).

Conversely, pastoralists on special purpose trips to the obsidian source would extensively prepare obsidian nodules into a ready-to-use form in order to minimize transport costs. In this case, individuals might prepare cores according to local needs. The more communities from across a region that access the quarry, the greater the palimpsest of diverse core designs should be expected at the quarry. Direct procurement by many groups would indicate more communal and cooperative forms of quarry access. Spatially, we could expect several different extraction and workshopping loci that correlate with different technological signatures of the heterogeneous groups using the quarry. Increased affiliation of communities using the site may produce more organized technological and spatial patterns—mimicking a signature of a single group as would be expected for hierarchical control. Therefore, in order to differentiate between the multiple forms of quarry access and use, it is important to consider broader settlement around the quarry, spatial patterns within the quarry site, and variability in lithic technological signatures.

Whether access to a source was hierarchical or heterarchical, there were certainly important social rules and expectations surrounding activities at the quarry. If the source was being accessed by independent, but affiliated, communities, it would have served as neutral ground, and a key point for spreading information through social networks like those of Elmenteitan herders (Bryan

1950: 34; Holmes 1919: 262). Obsidian access fits well within the potential range of responsibilities entrusted to young men or warrior age-sets among contemporary Maasai, Samburu, Pokot, and Turkana pastoralists in Kenya who left their family group, and often make long distance journeys to move or protect cattle, or to acquire cattle through raiding other groups (Larick 1985; Peristiany 1951; Spencer 2011).

All of these possibilities exist with the Elmenteitan, and testing different models for quarry control (i.e. Robertshaw 1990), and existence of a long-distance provisioning system (i.e. Ambrose 2001) require investigation at the central Elmenteitan Obsidian Quarry.

3.2.2 Challenges and opportunities

Quarries are dense palimpsests of lithic reduction, sometimes utilized for thousands of years. They offer significant research opportunities, but archaeologists interested in quarries also face the daunting task of making sense of large quantities of lithic debris. Aside from the sheer time investment involved in research at such localities, quarry deposits are often un-stratified, and un-datable, making it difficult to test between different depositional or use scenarios (Ericson 1984; Tripcevich and Contreras 2013). It is often difficult to devise sampling strategies that are intensive enough to capture variability without overwhelming analysts with high volumes of lithic debris. Furthermore, specialized activity sites like quarries and mines are unlikely to yield ceramics or other materials that might assist in correlating use with particular cultural groups or time periods.

Several of these often cited methodological challenges are, in fact, strengths for studies situated in the East African Pastoral Neolithic. It has always been difficult to understand regional processes and interconnections between communities in the PN because habitation sites are temporary and sometimes ephemeral, and where few sites preserve well documented evidence of

diachronic variation (Lane et al. 2004; Marshall 1990). Exhaustive excavations of habitation sites are required to produce useful sample sizes for comparisons, and these are not always logistically feasible. Quarries represent a single location in the landscape that captures and concentrates the lithic production signatures from a broader region, and/or a deeper chronology. Such rich deposits have the potential to reveal changes in reduction strategies at a landscape level and to provide data for interpreting regional relationships (Clark 2003; Darras 1994; Torrence 1984).

3.3 Archaeologies of exchange

Acknowledgement that even the simplest forms of material economy were embedded within modes of social relations brought trade and exchange systems to the forefront of anthropological discourse (Mauss 1954; Polanyi 1944, 1957; Sahlins 1972). Exchange is here defined loosely as a transfer of materials between parties without remuneration with currency. Foundational archaeological studies focused on tracing raw materials, artifacts, and foodstuffs have produced a range of conceptual and methodological approaches to studying exchange in prehistory (Earle 1982; Earle and Ericson 1977; Fry 1980; Glascock et al. 2007; Hodder 1982). Given the importance of obsidian exchange for this dissertation project, I will review key perspectives on archaeological exchange as they relate to the main research questions I have presented, and which inform later interpretations.

Archaeological studies of exchange are typically divided into formalist approaches based in predictive modeling and cost-benefit calculations (Earle 1982:2; Hodder 1982:201) and substantivist approaches that focus more on the social dimensions of exchange (Sahlins 1972). This study operates at a crossroads between these perspectives. Lithic technological organization

methodologies are clearly situated within an economically or energetically driven formalist approach, whereas ethnographic studies of recent herder exchange have been predominately analyzed for their social and political dimensions. Tracing lithic variation through an exchange network is, in a sense, looking at the actual economic costs and strategies associated with the highly social acts of maintaining alliances and managing resource scarcity (see Hodder 1982: 200). Pursuing this cross-cutting methodology requires a careful consideration of the reasons that ancient pastoralists may have been engaged in exchange, and of social mechanisms involved. Interpreting any dataset would be handled differently in the context of exchange for prestige, for example, than for exchange fueling political hierarchies, or down-the-line gift giving (Renfrew 1977).

3.3.1 Motivations for obsidian exchange

Obsidian is a high quality volcanic glass that fractures conchoidally in predictable way and was sought after as an ideal lithic material all over the world (Cann 1983:227; Dillian 2007; Dillian et al. 2010; Glascock et al 2007; Hughes 1978; Ndiema et al. 2010; Merrick and Brown 1984; Tripeceovich and Contreras 2009). Like other valued raw materials, the natural distribution of obsidian is heterogeneous, leading to the development of large scale, but low volume, exchange systems to facilitate access by distant communities (Glascock et al. 2007; Specht et al. 1988; Stevenson et al. 2004; Summerhayes 2004). Obsidian flows tend to have distinct geo-chemical signatures, permitting high resolution sourcing and the ability to trace these networks across large regional extents. Given that obsidian has a clear utilitarian value as raw material, but also carries social significance in many contexts, understanding the nature of these networks can be complicated (Dillian and White 2010). Even so, there is a significant body of literature on exchange systems that allow for the generation of testable hypotheses.

On its most basic level, exchange is a means of creating connections and maintaining relationships between individuals, groups, and societies (Renfrew 1984:86; Sahlins 1972:186). Reciprocal gift-giving creates social ties that also provide a context for distributing information and knowledge. Having good information about the environment and resources across a landscape becomes particularly important in unpredictable ecologies, providing a strong motivation to engage in these forms of reciprocity. Slightly more systematized, but still informal, forms of exchange can develop specifically to manage unpredictable access to resources (O'Shea 1981; Arnold 1992). Prehistoric herders in southern Kenya could have engaged in this type of informal exchange given the spatial discrepancy between good grazing lands and obsidian source locations. This does not, however, explain why Elmenteitan pastoralists so clearly insisted on obsidian from the Mt. Eburru source group. Maintaining that source specialization required a fair amount of social organization (Ambrose 2001: 201).

A major question, posed by Robertshaw (1990), is whether social hierarchies played a role in organizing Elmenteitan exchange. As he argued, such a relationship would not be uncommon amongst smaller scalar societies. Control or management of important resource nodes can provide the basis for, or be derived from, inequalities (Arbuckle 2012; d'Altroy et al. 1985; Schortmann and Urban 2004). Unequal access to resources like obsidian could be leveraged into status, even if that status is ephemeral. Groups controlling a quarry, or influential middlemen within an exchange network, have the ability to manipulate supply and thus gain political power (Earle 1997; Schortmann and Urban 2012).

A rise of a more temporary form of elites is possible even if the quarry was not under formal control. For example, individuals in New Guinea could gain social prestige and wealth by being better able to develop trade friendships across the landscape (Hughes 1978). If materials

become interconnected with the prestige and value associated with social inequalities, the material themselves can become symbolically important. This reinforces the social importance of maintaining access, in turn re-ifying the authority of those responsible for acquiring the raw material. In time, subtle social value of involvement in exchange can build in this way into a very real social differentiation (Arnold 1991; Brumfiel 1992; Hantman and Plog 1982: 241).

Symbolic or social value of artifacts and materials constitutes a third possible motivation for the development of regional exchange networks for obsidian. As discussed, obsidian is often valued for its color and aesthetic qualities as much as its practical utility (Dillian and White 2010; Hughes 1978). If these physical properties are unique to a specific region or source group, obsidian can become associated with those groups who have access. Possession of a certain material, access to that material, the material itself, or some combination thereof comes to constitute an important signifier identity (Bayman 2010; Hodder 1991). In order to continue participating in the socially constructed identity, access to the resource needs to be maintained, spurring intensification of exchange (Spielfmann 2002).

Options presented are not mutually exclusive, but different motivations should produce slightly different patterns for resource access and deployment of exchange. Resource exchange aimed to mitigate resource risk should manifest in forms of redistribution (Torrence 1986). In some cases, like that of Andean pastoralists, there is evidence that communities maintained consistent access to obsidian through social exchange networks (Tripcevich 2007, 2010). This sets these systems apart from simple down-the-line trade patterns where resource access trails off with distance (Renfrew 1977). Access to obsidian in smaller nodes would be diminished as it moves through various communities based on their position within the social hierarchy.

Obsidians that were exchanged for their significance in structuring identity present an interesting options for acquisition. Individual communities may want to ensure their own access by sending representatives to obtain raw material, carry it back to the site, and then subsequently to exchange it amongst trade-friendship networks (Dillian 2002). Such trips may occur regularly, with constant movement of obsidian among communities. Alternatively, these acquisition episodes could be seasonally scheduled. This has been proposed in Andean contexts where important rituals and gatherings served as the context for large episodes of obsidian exchange between communities (Browman 1990; Tripcevich 2007). When combined with models of exchange, expectations and lines of evidence obtained through quarry archaeology and lithic TO analysis (elaborated above), it is possible to identify how and why pastoralist obsidian exchange networks developed in eastern Africa.

3.4 Exchange, identity, and social boundaries

Considerations of the role of materials exchange have a deep legacy within anthropology, often emphasizing the highly social nature of systems of exchange (Dalton 1969; Mauss 1954; Hughes 1978; Oka and Kusimba 2008). One of the most important themes to emerge centers on identity as something that forms out of the dialectical relationships between people's engagement with material and their involvement in social exchange (Miller 2005). If material is used in constructing identity, rather than simply be a reflection of it, then the archaeological record offers many opportunities for addressing the variable manifestations of identity in the past, and ways in which they shaped human social, economic, and political trajectories (Hodder 1991; Wynne-Jones 2007). Evidence for trade and exchange thus offers insight into the interactions between

individuals, among groups, or among whole societies that serve as the medium for renegotiating identity on many scales. The articulation of materiality and trade in constituting identity is thus a powerful concept for social archaeologies.

Material culture is increasingly discussed as important in building, maintaining, and restricting identities (Hodder 1991:63; Miller 2005; Wobst 2000). That is to say that, at least in part, we define ourselves through our negotiations with materiality. Rather than seeing artifacts as representations of cultures or identities, approaches must expand to the role of material in building identity. If this dialectical relationship is to form the basis for future work on identity within archaeology, then investigations of trade and exchange are necessary for understanding the causal mechanisms structuring how material is obtained and transferred.

Material exchange is also a critical source for changing identity. Cultural reformations are multi-directional, affecting participating parties in different ways (Hoffman et al. 1997). The important point is that the very act of engaging with materials is part of the process of placing oneself, or ones group, within a social world. Because engagement with materials never ends, the renegotiation of identity is forever ongoing, and largely affected by the historical and contextual circumstances of that engagement. Whether or not identity exists outside of material entanglements, materials remain the only line of evidence available for archaeologists to reconstruct identity. For the archaeologist, then, material *is* identity. This is not to say that materials are simple one-to-one signifiers for identity, but it means that the constitutive nature of material in negotiating social identities must be taken seriously (Meskell 2005; Wynne-Jones 2007).

3.5 Archaeologies of learning

Archaeologists working in eastern Africa have long sought to develop a more comprehensive social and cultural framework for studying early herders to complement the detailed economic analyses of the 1980's and 1990's (Gifford-Gonzalez 1998b, 2005, 2016; Marshall et al. 2012; Prendergast and Mutundu 2009). Lithics, one of the most abundant forms of material culture in the Pastoral Neolithic record, provide an avenue for such an endeavor if we recognize technology has a role in social (re-)production and change (Dobres and Hoffman 1994). This is to say that the spatial and behavioral patterns surrounding tool manufacture, use, repair, and discard are embedded within social realities. Identifying learning also aids in interpreting lithic variability.

Ethno-archaeological studies make evident that interactions with lithics are nearly always structured by at least age and gender (Lemonnier 1986; Leroi-Gourhan 1964; Roux and Bril 2005; Sellet 1993; Weedman 2002a,b). By establishing how learning occurs in non-western contexts, these studies have been integral in developing models for reconstructing learning and cultural transmission in the ancient past. These include both theoretical and conceptual maps for discussing the issues of learning and skill.

3.5.1 *Practice theory and learning*

Practice theory provides a useful framework for connecting the individual actions and decisions around lithic reduction with the broader social structures affecting *how* and *what* novices learn *when* (Bourdieu 1977; Giddens 1979; Lightfoot et al. 1988). A major advantage of this approach is its allowance for a degree of experimentation on the part of the novice, while

understanding that all knapping endeavors occur within a cultural atmosphere (Bamforth and Finlay 2008; Tostevin 2013). Additionally, practice theory allows for consideration of multiple communities of practice to operating simultaneously, such as males and females, novices of different ages, and different social groups within a single community who may engage in learning in very different ways (Conkey 1991; d’Errico and Banks 2015; Karlin and Julien 1994). Archaeologies of lithic learning then, are windows into discussions of broader social structures involved in maintaining ancient traditions.

Recognition that assemblages may reflect large degrees of practice and play presents a problem for lithic analyses grounded in the behavior-ecological traditions of Binford (1979, 1980) and M. Nelson (1991). It is difficult to discern the adaptive value of technologies when data-sets also include an indeterminate amount of debris reflecting learning and play, rather than task oriented tool production. As John J. Shea (2006: 214) and Peter Hiscock (2014) have pointed out, novices produce more waste debris when learning and are less likely to clean up after themselves. Novice waste may make up a large percentage of assemblages going back to the origins of lithic technology itself (see Want and Harris 2002). Rather than ignoring the issue, many lithicists have prioritized the identification of learners in the archaeological record to mitigate the “novice bias” (Cavalli-Sforza and Feldman 1981; d’Errico and Banks 2015). There is a growing body of theoretical and methodological approaches for testing hypotheses related to lithic learning (Andrews 2003; Bamforth and Finlay 2008; Bleed 2008; Finlay 2008; Grimm 2000; Lassen and Williams 2015; Roux et al. 1995; Shelley 1990; Takakura 2013).

Investigations of learning in the archaeological record are concerned with understanding the process of learning itself, which has significant implications for social structures. Experimental projects aimed at learning rely on the modern, western, dynamic of apprentice-master in the

process (Eren et al. 2015; Eren et al. 2011; Stahl 2008). These studies provide invaluable data for quantifying skill and proficiency, but are less applicable for studying non-stratified societies, wherein teaching and learning do not occur in formal environments (Hayden and Cannon 1984:331). A number of alternative modes of learning have been outlined by the recent work of d’Errico and Banks (2015). They provide some useful terminology for thinking about lithic learning may have occurred at a prehistoric quarry. Possibilities, for example, differentiate between sequential information transfer, where skills have to be acquired in-order, and modular information transfer, where different sets of technical skills can be acquired independently. At a quarry, the actions of lithic extraction and core preparation can be considered modular units, whereas learning blade reduction requires actions preformed in sequence.

More important is how these skills are transferred. Transmission can be horizontal or vertical between generations (Boyd and Richerson 1985; Cavalli-Sforza and Feldman 1981; Shennan 2002). The age-grade model of training (e.g. in herd management, warfare or ritual knowledge) common amongst Nilotic speaking herders in eastern Africa primarily represents horizontal transmission, with learning being a more cooperative act between age cohorts. This is different than vertical transmission, with teachers or masters educating either their own children or the children of community members. Vertical models often involve skill transmission via “scaffolding”, where younger learners are directly integrated into the work of older, more skilled, individuals (Bamforth and Finlay 2007b; Minar and Crown 2001: 370; Wood et al. 1976).

3.5.2 “*Communities of Practice*” (CoP)

The different traditions for passing on knowledge, and the specific settings and strategies of learning, constitute what can be called “communities of practice” (Lave and Wenger 1991;

Wenger 1998). The sharing of knowledge and experiences on testing and selecting obsidian nodules, removing flaws, preparing cores, removing blades, and manufacturing tools would have occurred within the physical setting of the Elmenteitan Obsidian Quarry. Participation builds a set of shared and understood behavioral norms and conditions relationships between experts and novices. The “joint enterprise” or “domain” (Wenger 1998) of the community, or its set of shared goals to quarry and transport obsidian, bind the participants under a shared identity. Information, tools, and learning structures are shared within this community of practice to (1) facilitate the enterprise of quarrying and (2) ensure that necessary knowledge and skills are transmitted. Interrelationships between individuals forged within a community of practice around quarry could, following the network models described by Gulliver (1974) be re-negotiated and/or invoked for different kinds of interactions like trade, inter-marriage, or livestock lending. For this reason, understanding the social settings of quarrying and lithic extraction are just as vital to this research project as identification of the archaeological patterns themselves.

3.6 Measuring skill in lithic assemblages

Whether we are discussing the chert eccentrics created by specialized Maya craftspeople or utilitarian blade cores used by African pastoralists, parameters of any lithic tradition have to be transmitted to each successive generation (Andrews 2003; Bamforth and Finlay 2008:9). The transmission process is not instant. Depending on the complexity of final products, becoming even proficient in a full suite of knapping techniques can take several years of social learning, beginning at a young age (Finlay 1997:210, 2008:70; Pigeot 1990; Pelegrin 1990; Stout 2005). Archaeologists are concerned with quantifying this process of skill acquisition. Skill is variably

defined, but can be considered an individual's technical proficiency in achieving a desired outcome given available means and materials (Bleed 2008:156; Roux et al, 1995:66; Stout 2002:705).

3.6.1 *Operational sequences*

Archaeological discussions of skill have been biased toward recognizing the artisan-level production of bifaces and blades associated with men, hunting, and inter-personal violence (Apel 2008; Flenniken 1978; Whittaker 1987). Archaeological and ethnoarchaeological studies demonstrate the technical complexity of "expedient" methods more often associated with women, and moreover are deconstructing simplistic assumptions about gendered divisions of tool-use (Bamforth and Finlay 2008; Weedman 2002). This endeavor is aided by more recent studies focused on reconstructing lithic operational sequences, or *chaîne opératoire*, in studying skill (Grimm 2000; Pelegrin et al. 1988; Julien and Julien 1994). Operational sequences with separate production strategies and reduction trajectories associated with certain core and tool types could be argued to reflect gendered, age-based, or skill-based task groups.

Identifying skill, or lack thereof, can be accomplished through the identification of mistakes that occurred in the core reduction process. This is easier in instances where large refit sequences are possible, and core knapping episodes can be attributed to an individual, but mistakes can also be evaluated on a flake-to-flake basis (Pigeot 1990). Typical mistakes are step and hinge terminations, overshoot flakes, split cores, and flakes with aberrant morphologies (Clark 2003; Crabtree 1972; Eren et al. 2015). Such mistakes are usually the result from a failure to properly platform preparation, a misapplication of force, or failing to reset blade release surfaces or prepare crested blades (Finlay 2008: 81). Even if flakes are successfully struck, some aspects of improper preparation leave visible traces that can be used to infer skill level. Either due to inexperience or

lack of physical strength or dexterity, learners and novices tend to be unable to problem-solve and remove such mistakes, and so accumulations of multiple step fractures, or multiple mis-strikes from unprepared platforms are strong indicators of low skill (Andrews 2003; Finlay 2008:87; Milne 2012; Roux 2005).

3.6.2 Core preparation and reduction

Core preparation, the activity that dominates quarry assemblages, requires more than just technical skill in flake release. A knapper has to envision several reduction steps and stages from the early cortical removals, to shaping, and to preparation of platform, and surface preparation in advance of removing an initial flake sequence. Experience, more than any other variable, is necessary for successfully preparing complex cores, like those used by Elmenteitan producers. Experimental studies demonstrate that technological attributes are quantifiable such that experts and novices can be identified, albeit with some degree of error (Bleed 2008; Eren et al. 2011, 2015; Pelegrin 1990; Stahl 2008). Core organization has been successfully applied in archaeological contexts as an additional proxy for skill (Bodu et al. 1990; Grimm 2000: 54; Pigeot 2010; Takakura 2013).

Standardization, the consistency in form of end products, is also considered to be a measure of skill in lithic production (Costin and Hagstrum 1995; Eerkens 2000; Eerkens and Bettinger 2001). This might be applicable for the Elmenteitan, where specific forms of long, flat blades, are typical (Ambrose 1984, 2001; C. Nelson 1980). High skilled reduction sequences should show lower variability in morphology and attributes, whereas novice knapping is likely to produce a wide range of flake shapes. There are thus several suites of characteristics that can be used to evaluate skill in lithic debris. Finally, there is speculation that novices are trained with lower-

quality materials. Identification of differential core *chaîne opératoire* between raw material types or qualities serves as an additional line of evidence for novices.

It is important to note, however, that while we can define attributes related to how much skill a person *employed*, it is not always a consistent measure of skill that person *possessed*. An ethnographic example is highlighted by Stout (2002:705) who observed an individual recognized by the Langda community as an expert producing novice level products. Again, the act of production allows individual agency to shape results. This can be hard to recognize archaeologically, but must be considered as a possibility when evidence of low-skilled knapping is identified. Specific measures and quantifications are discussed in the Methods sections.

3.6.3 Implications of lithic learning at the Elmenteitan Obsidian Quarry

Children learning to knap are unlikely to focus solely on quarrying and core preparation while on Mount Eburru. At the behest of older and higher ranked individuals, the learners may also have been responsible for cleaning up the copious lithic debris resulting from learning, gathering fuel or plant resources, and helping with cooking or other tasks, as documented by Grimm (2000) and Lillehammer (1989) in ethnographic contexts. Stout (2002: 333) notes that a desire of young Langda males to make the trip to the quarry with experts is the first step in their eventual apprenticeship.

Engagement in special purpose tasks away from the community also provides an ideal opportunity to impart general information or special knowledge to learners. This is especially true when learner cohorts are structured by age or gender. In such contexts, the passing on of “practical knowledge” is a venue to impart “knowledgeable practice” (Ingold 1993: 433). Numerous ethnoarchaeological examples demonstrate how this might have worked in the past. Production

and learning cohorts are the bases for social relationships underlying ceremonial *moka* exchange and semi-formal exchange friendships (Strathern 1971). In Langda, New Guinea, the process of learning to produce stone adzes is seen as a means of establishing young people's membership in communities (Lave and Wenger 1991). The engagement of novices in learning tasks at the quarries creates social bonds between cohorts.

Even with the development of metrics for evaluating skill, learners (i.e. children) remain difficult to detect in the archaeological record. Learning tends to take place in peripheral locations, away from central activities of sites, and thus away from the focal areas of most excavations (Grimm 2000). In the case of the Elmenteitan pastoralists, the preference for obsidian imported from up to 250 km away made obsidian cores precious resources. Allowing novices to engage in the highly wasteful process of learning would not likely be an attractive proposition. We might expect that, in response, a significant amount of learning may have taken place at the quarry itself where high quality obsidian was abundant. Grimm (2000: 56) and Porr (2005:77) have pointed out the important that role raw-material availability plays in where and how learning take place, and the circumstances at quarries make them ideal for lithic learning.

The Elmenteitan Obsidian Quarry is the best candidate site for studying learning processes amongst prehistoric pastoralists in Eastern Africa. A quarry is also a location where we might expect an artificially high number of mistakes with or without a learning component to site use. This trend is referred to by Clarke (1935) as the “Brandon Bias”, and was qualitatively established for quarries and workshops where people were preparing bifaces. Mistakes on specialized blade cores are more catastrophic than those on bifaces, and so people should have been incentivized to reduce mistakes when preparing cores at the Elmenteitan quarry.

Additionally, blade cores are not the product themselves but the means to produce blanks. The goal of reduction at the Elmenteitan quarry would likely have been manufacturing ready-to-export cores, and the remaining debitage should reflect that intention. If debris and core modifications reflect counter productive design and reduction, it may be assumed that these reflect an issue of true skill rather than haphazard knapping. Counter to the Brandon Bias, ethnographic observations of flintknapping demonstrate that successful removals are a source of pleasure and pride of the producer who often “calls out in excitement” (Stout 2002: 334). There is thus incentive to “show off” when the social setting of knapping involves a higher ratio of peers.

Archaeological excavation and analysis at the Elmenteitan Obsidian Quarry provide lines of evidence that can test hypotheses and expectations of learning occurring at the site. If it becomes possible to discuss learning processes here, it may help inferences regarding the social and cultural structures of learning among the Elmenteitan. Even more importantly, if learning is a major factor affecting the formation of the lithic assemblage, it could fundamentally alter any economic or environmentally driven interpretations.

3.7 Research questions

To answer questions relating to the technological organization of Elmenteitan pastoralist obsidian exchange and related social structures, I apply a technological organization framework to the study of the Elmenteitan Obsidian Quarry site (SASES GsJj50) on Mt. Eburru. This locale has never been systematically studied as an archaeological site. Here, I investigate the nature of obsidian access and distribution by addressing two research goals reflecting assumptions for the models proposed by Robertshaw (1990) and Ambrose (2001). My goals are to:

- 1. Identify any spatial patterns to quarrying activities.**
- 2. Quantify the intensity of core reduction and the morphological variability in blades, cores, and core modification debris at the quarry site.**
- 3. Evaluate the possibility that the Elmenteitan Obsidian Quarry was a venue for learning lithic reduction skills.**
- 4. Describe patterns of lithic technological organization across the Elmenteitan.**

Links between these goals and archaeological and anthropological models and specific research hypotheses are set forth below.

3.8 Archaeological expectations

(1) Spatial patterning.

Quarrying activities were spatially organized at the Eburru quarry. Evidence supporting the spatial organization as a result of hierarchical control of the quarry or exploitation by a single group would consist of survey data revealing only a few discrete quarry and workshop loci. There should be very few obsidian extraction sites relative to the distribution of the obsidian source across a 100 meter extent of Mt. Eburru, reflecting the intensive use of specific outcrops. I predict that these outcrops would be the most easily accessible outcrops where homogenous obsidian is exposed. A concentration of reduction areas where nodules were tested and prepared into cores, close to extraction sites would signal consistent use of areas specifically designated for these activities.

Quarrying activities were spatially variable at the Eburru quarry. It is possible that obsidian was actively extracted from a number of points across the surveyed extent of the obsidian flow

across Mt. Eburru. Where people chose to quarry could have depended on various factors including knowledge of the area, ease of access, and the relative quality of obsidian available. In this case, obsidian nodule reduction would have occurred at spatially disparate locations, with no consistent correlations between quarry and workshop areas. The resulting pattern would be numerous small core preparation areas relative to the number of high quality obsidian outcrops detected during surveys. If there is only a single high quality obsidian source, a decentralized pattern of use could be discerned from relatively low artifact densities in the vicinity. This variability would reflect the extraction of obsidian by numerous separate groups, which independently traveled to the quarry throughout the Pastoral Neolithic. A highly variable spatial pattern would, at least, refute an organized exchange network model.

(2) Reduction intensity and variability

Core were minimally prepared at the Eburru quarry. This hypothesis is focused on the intensity of preparation, independent of morphological form. The presence of primarily cortical flakes and other early stage debris, with little representation of late-stage debitage or platform preparation and rejuvenation flakes would support this hypothesis. This can be quantitatively assessed by using percentage of surface cortex on flakes and remnant cores as an indicator of core reductions stage (Dibble et al. 2005; Lin et al. 2009). The largest blade tool blanks typically present at habitation sites are around 15cm long. If cores were leaving the quarry without being fully prepared, failed or abandoned cores should have flake release surfaces longer than 15cm. Likewise, most whole flakes should fall into large size classes, with few, if any, prismatic blades.

Cores were intensively prepared at the Eburru quarry. This hypothesis would be supported if analysis of cortical flakes and an abundance of late stage shaping debris shows that cores were

fully, or at least extensively, prepared into ready-to-use forms before leaving the quarry. There would be evidence for continued shaping even at low percentages of remaining cortex. Intensive reduction suggests that people at the quarry were attempting to limit transport costs associated with any one groups' return distance to their native community (Beck et al. 2002). Furthermore, the presence of platform rejuvenations and a high frequency of formal blades would suggest that individuals were actively replenishing their own toolkits while at the quarry, and not concerned only with long distance exchange.

Core production at the quarry reflects a standardized reduction strategy. If metric analysis and attribute classification, of lithic material at the quarry reflect a narrow range of core morphologies (to be discussed below), then it suggests a standardized reduction strategy of a specific economic group (Kuhn 1991; Parry and Kelly 1987). Variability in design must be very low to support the model of control over the source proposed by Robertshaw (1989). The systematization and standardization of core production would indicate a small number of Elmenteitan groups exploited the Eburru quarry during the Pastoral Neolithic. The controlling groups imposed a consistent core design, with a limited range of variation in reduction sequence. If spatial patterning can be discerned, it could also be used to test this hypothesis. A small number of concentrated dense deposits would indicate the level of social organization around quarrying expected from a centralized group's activity.

Core production at the quarry reflects a diverse range of reduction strategies. The existence of several divergent core morphologies and reduction strategies is expected to reflect planning for a range of economic activities by small groups traveling to the quarries. No central authority or group is likely to have controlled access to obsidian if cores were prepared for a diverse range of strategies. In this case, Mt. Eburru likely served as a neutral ground for Elmenteitan groups to

quarry obsidian and exchange information with distant communities. This pattern would be consistent with people travelling directly from home-bases to the quarry and preparing for the needs specific to their families, environmental conditions, or regional economies (Close 1999).

(3) Evidence for learning

Understanding and evaluating the likelihood of lithic skill learning in the archaeological record is a difficult proposition, and requires a more explicitly detailed set of archaeological expectations. Identifying errors, mistakes, and failures to properly modify cores is easy, however the analyst must then fit the patterns of error-rates into a model that presupposes skill displayed reflects skill possessed. The best approach is thus to construct a series of nested expectations for how learning should manifest given the technological and logistical specifications of Elmenteitan quarrying and core production.

Rates of errors should, overall, be higher at the quarry site. I expect that learning would occur at the site primarily as a matter of convenience, as it would allow important skills to be passed down without wasting large amounts of culturally valuable, imported, raw materials. Again, while learning could take place at the habitation sites with lower quality materials, this would likely not translate to practical skill working large obsidian cores (See Pargeter and Duke 2015). A high degree of learning and practice at the Elmenteitan quarry should be reflected in a higher rate of production mistakes. This does not rule out the “Brandon Bias”, but is a first step in testing for lithic learning. If this expectation is not met, it would hold that it was primarily experts who were sent on quarrying trips, as noted for the obsidian quarry studied by Carolyn Dillian (2002).

Error rates and error types should be patterned relative to blade size. Unlike bifacial technologies, blade cores are not the product in and of themselves, but simply a means to produce

blanks. Activities at the quarry should be focused on the preparation of cores, which can then be exported to Elmenteitan communities. The largest blades found at Elmenteitan habitation sites are between 10 and 15 cm in length (Robertshaw 1990, Ambrose 1980; Goldstein 2014:12). Assuming this is roughly the maximum length of the cores these communities received from the quarry, it holds that most of the reduction debris at the Elmenteitan Obsidian Quarry should reflect reduction of cores over 10cm long. If data supports significant reduction of cores under 10 cm in length, it could reflect intensive practice and learning due to that blade debris having been disposed of at the quarry without being used.

Figure 3.1. Expected distributions of error rates for knappers of different skill levels through the blade core reduction sequence.

Large ratios of blade production errors are expected, irrespective of learning taking place or not (Clark 1997, 2003). Differentiating between experts who are not employing their skill and the work of novices requires consideration of how mistakes are distributed in the blade assemblage. Experienced knappers will be aware that major failures are likely to occur in the initial phases of reducing an obsidian nodule due to internal flaws in the material or the often unpredictable nature of removing cortex. Experienced individuals may also realize early in the process that they will not be able to easily shape the particular piece, and abandon it for another. Even experts may, as a result, put little effort in these early stages of core reduction, and produce more mistakes and errors. As the core approaches ideal size and shape for export, the expert is expected to put more and more effort into the preparation process, and the rate of errors should rapidly decline as cores approach the 10-15cm mark. After this point, error rates should steadily decrease as blades become easier to remove as the core length decreases.

A novice reducing cores will also incur high error rates early in the core process, but will not have the skill necessary for the critical shaping stages. Novice error rates should not rapidly decline at any point, but steadily decrease in frequency in frequency as core length decreases. This pattern might be exaggerated or inverted if the quarrying and early stage testing was a task preferentially given to novices. Even these will produce patterns that diverge from the “optimal” pattern expectations, and would not refute the possibility that learning occurred at the quarry site.

(4) Elmenteitan technological organization

Using the data-sets produced through research goals 2 and 3 focused on quarry patterns as a foundation, I will compare lithic technological signatures at the quarry to Elmenteitan assemblages across southern Kenya. One of three patterns is expected: (1) There is regional

variation in Elmenteitan technological organization relating to environment; (2) there is technological variation that patterns in relation to distance from the quarry, and thus relates to obsidian access; (3) Elmenteitan technological patterns appear homogenous across space and time. These possibilities would have different implications for the organization and consistency of obsidian exchange and distribution systems, as well as for interpreting the nature of the Elmenteitan as a cultural group.

Chapter 4

STUDY AREA AND RESEARCH SITE

4.1 East African environments and ecologies

This chapter presents the geological and ecological setting of the Central Rift Valley, Kenya within East Africa in order to properly contextualize Elmenteitan use of the Elmenteitan Obsidian Quarry on Mt. Eburru.

A complex geological history of rifting and volcanic activity at border of the Somali and Nubian continental plates has produced a highly variable mosaic of environments across East Africa. Environmental variability and resource distributions throughout East Africa offered very different opportunities and challenges to early pastoralists. The deep lakes that formed within the bottom of the Rift Valley have no outlet to the ocean, and are prone to salination and high mineral content, especially during dry phases. Lakes Baringo, Nakuru, Elmenteita, and Naivasha, dot this length of the Rift system, providing dependable access to lacustrine resources and littoral grazing. Surrounding the lake basins from Turkana to Tanganyika within the rift are semi-arid plains. Savanna grasslands on these plains expanded and contracted in response to changing rainfall patterns through the Holocene, and had begun to approach the modern environmental condition after 3000 BP (Ambrose and Sikes 1991; Garcin et al. 2011).

The southern Rift Valley, bounded by the volcanic Mau Escarpment to the west, and the Nguruman Escarpment to the east, is a likely corridor for the initial spread of pastoralism into southern Kenya. Rifting has created rapid altitudinal zonation between the rift floor, high plains, higher rainfall montane forests, and montane moorlands providing a wide range of ecotones available for human exploitation (Ambrose 2001: 98). The floor of the rift is dominated by

savanna grasslands/plains with intermittent open woodlands that grade quickly into the more forested escarpment highlands. Above 2400 meters these transition to montane forests and moorlands (Ambrose 1984c). The highland plains in southwestern Kenya are dominated by open-to-wooded grasslands that are interrupted by occasional metamorphic inselbergs. Much of the early Elmenteitan herder occupation was focused in these highlands, especially along the Mau Escarpment, and in the Loita Hills and Loita-Mara Plains.

Soil fertility is overall high across the region due to enrichment from volcanics, especially in areas that have experienced more recent volcanic activity. Differences in elevation, slope, drainage, and other factors across the Rift System do affect variability in overall soil productivity, and thus the distribution of above- and below-ground edible plants, foliage, the density of herbivore species (Ambrose 1986). Volcanic soils support particularly rich foliage for domesticated stock, incentivizing utilization of these regions by modern, and early, pastoralists. Ongoing volcanic activity has also concentrated obsidian sources within the savannas on the floor of the Rift system, and along the slopes of volcanic complexes like Mt. Eburru.

Southwestern Kenya experiences two rainy seasons per year, as the Inter-Tropical Convergence Zone bring dry air from the Persian Gulf as it retreats south between November to April, and then and brings warmer air from Congo Air Basin and Pacific Ocean as it moves northward from May to October. Human subsistence strategies must be structured around the timing and regularity of the long rainy seasons. The distribution of rainfall varies widely across the region. Less than 250 mm of annual rainfall is common for the lowlands around southern Sudan and Ethiopia and northern Kenya, while the south-western Kenyan highlands experience annual rates between 250-900 mm. These environments have hosted a spectrum of foraging, herding, and

agricultural strategies, however the study here is focused on economic activities within the Central Rift Valley system specifically.

4.2 Mount Eburru

4.2.1 Geology and ecology

Mt. Eburru, the center-point for Elmenteitan obsidian exchange, is a low volcanic massif with an east-west orientation, located just north of Lake Naivasha, within the Central Rift Valley of southern Kenya. At its highest point, the mountain is 2856 m above sea level, and in total it covers 470 sq. km. Eburru has two peaks; the eastern Eburru Hill whose slopes grade down into the Naivasha Basin, and the slightly larger West Hill, which connects the volcanic complex to the eastern edge of the Mau Escarpment. Both are composed largely of trachytic lavas, with deposits of pumice, and volcanic ash. West Hill is dominated by large craters formed through intensive volcanic activity that has persisted through the last few hundred years, whereas the eastern Eburru Hill was largely formed out of pyroclastic eruptions ending in the early Holocene (Clarke et al., 1990; Ren et al. 2006).

One of the most notable features of the mountain is the presence of fields of volcanic fumaroles and steam vents across the upper slopes (above ~2400 m asl) of the Eburru Hill. The name “Eburru” derives from the Maasai place name “*Ol Doinyo Oporru*”, which translates as “the mountain of steam”. Other remnants of a highly active volcanic past including large ochre deposits, cinder cones, trachytic uplifts, rhyolitic domes, and obsidian outcrops (Woolley 2001). The promise of active volcanism interested explorer Joseph Thomson who visited the upper slopes of the mountain with Maasai guides in 1884. Thomson noted numerous geological occurrences of

obsidian near steam vents that emitted “... clouds of vapour and a curious sound exactly resembling a steam-engine starting work” (Thomson 1887: 341).

High annual rainfall at these altitudes contributed to the development of rich andisols that now support forests with a wide range of tree species including *Acacia* spp., *Allophylus abyssinicus*, *Ekebergia capensis*, *Olea* spp., *Juniperus* spp., and *Podocarpus* spp., among many others (Chapman and Chapman 1996; White 1983: 121-129; Young 1996: 406). Small rain-fed streams extend from the flanks of the forest down the western and southern slopes of the mountain, however there are no permanent sources of potable water on the eastern Eburru Hill, where the obsidian sources are located. It is not clear what land cover was like through the Holocene, although it reasonable to expect that the distribution of different plant species fluctuated with climate and rainfall patterns.

4.2.2 Prehistoric land-use

Mt. Eburru had a long history of human occupation before the arrival Elmenteitan herders. There is abundant evidence for prehistoric Middle and Later Stone Age sites around the mountain, primarily along the northern and southern flanks (Clark 1988; Ambrose 1998). The LSA sequence is overall much richer, with the most well known industry being thoroughly described as the “Eburran”, which is divided into five technological and temporal phases (Ambrose 1984, 1988, 2002). Diagnostic Eburran toolkits were made by foragers whose lifeways were adapted to the montane forest-savannah ecotones in the vicinity of Mt. Eburru (Ambrose et al. 1980, Ambrose 1986). The Eburran industry is typically described as being centered on the mountain after which it is named, and several major archaeological examples of the industry are present within horizons

at sites nearby, such as Nderit Drift, Masai Gorge, Gamble's Cave, and Enkapune ya Muto (Ambrose 1984c; Wilshaw 2016).

Settlement patterns changed through the Late Pleistocene and Holocene in response to environmental fluctuations (Ambrose 1998; Lane 2011; Mutundu 2010). There are, at present, few documented examples of Eburran settlements in the immediate vicinity of the quarry site, or elsewhere on the upper slopes of the mountain. Ambrose (pers. comm.) has observed Eburran material eroding from contexts between volcanic tuff levels in areas further upslope from the quarry.

Figure 4.1. Ochre and steam-vent exposure at Eburru Center with condensers over steam-vents.

4.2.3 Historic land-use and implications for prehistory

Reconstructing human activities on the mountain over the last century provides insight into how this area could have been used in Mid-to-Late Holocene. The lack of fresh water has been a major impediment to long term occupation on the upper slopes of Eburru. Modern habitation was made possible in 1919 by British settlers who began building simple tube condensers to extract potable water from natural steam-vents. Maasai community elders currently living on Eburru recall visits to the East Hill to graze goat and sheep herds on the rich vegetation, and having used it as a shortcut while traveling between Lakes Naivasha and Nakuru. No one with whom we spoke recalls there ever having been long term Maasai homesteads on the upper slopes, citing the lack of water, high rainfall, and thick forests as reasons why such a placement would have been undesirable. The patches of forest and occasional small caves were, however, preferred locations for *moran* meat feasts (*ol-pul*) (see account in Thomson 1890).

Okiek forager communities persisted further up the highland Eburru forests, and there are anecdotal accounts of early farmers encountering the remnants of an ephemeral Okiek village somewhere on the upper East Hill. In 1982 there was a small Okiek village next to the forest ranger station on the west side of Eburru town (Ambrose pers. comm.). Individuals from all communities also traveled up the mountain to harvest medicinal plants. The relative isolation of the upper slopes also provided an ideal refuge for MauMau fighters, who used the forests and small caves as hiding places during the 1960 uprising. This historical sequence suggests that there was very little, if any, anthropogenic disturbance to the archaeological site between the final abandonment of the quarry by Elmenteitan producing groups and the modern occupation.

It was not until the late 1950's to early 1960's that the government's "Eburru Settlement Scheme" finally began to succeed in seriously attracting farmers (predominately displaced Kikuyu

speakers) to the upper slopes. The area around the Elmenteitan quarry was a particularly attractive plot of land because it sits on a relatively flat 100m ledge along what is otherwise a steeply sloped hillside. Kikuyu elders still living in Eburru Town remember participating in initial land clearing, field preparation, and construction projects in the areas immediately surrounding the GsJj50 archaeological site. Landowners also report using the large obsidian cores they found to help build small agricultural terraces, and I was able to confirm this by visual inspection. At present, much of the site lies under modern agricultural field. These fields are hand-dug and tractors are not in use. The geothermal potential of Eburru is now being exploited by KenGen geothermal wells, however the most significant modern feature of the mountain is the large cellular telephone tower that sits on top of a large basalt outcrop that forms the highest point on Eburru Hill.

4.2.4 Previous research

The importance of the Elmenteitan Obsidian Quarry has long been recognized within research on the Pastoral Neolithic. One of the earliest published references to the prehistoric exploitation of obsidian from Mt. Eburru comes from Mary and Louis Leakey's report on the excavations at the Njoro River Cave site (M. Leakey and L. Leakey 1950). They attribute the distinct green-hued obsidian artifacts in the Elmenteitan assemblage to sources on Eburru, citing it as the only known location where such material could be found. There is no mention of a large Elmenteitan quarry site on upper Eburru, and it is unclear how much material was evident on the surface or in road cuts at that time. It was not until 1980 that Stanley H. Ambrose documented large quantities of obsidian debris eroding from a roughly 400m extent of roadcut north of the small village of Eburru Center. This material occurred in the immediate vicinity of several large exposures of raw obsidian and appeared to reflect early stage core preparation.

The site was given the SASES code GsJj50, and was named the “Elmenteitan Quarry Site”. Analysis by Dr. Ambrose of surface collections taken in 1984 revealed that all diagnostic elements exhibited traits of the Elmenteitan industry of the Pastoral Neolithic component of the Later Stone Age. Additionally, a single fragment of mica-tempered, undecorated ceramic was recovered during these surveys that matched ceramics from Elmenteitan sites elsewhere. Although the quarry has been well known for several decades, there had not been any archaeological excavations until the research project reported here. The quarry site and source group has been visited periodically by researchers during the course of obsidian sourcing projects (see Ambrose 2012). Dr. Ambrose conducted initial informal surveys, and identified the four densest concentrations of obsidian flake debris eroding from road cut exposures.

4.3 The Elmenteitan Obsidian Quarry (GsJj50): Site location and approach

The trachytic obsidian flow quarried during the PN runs roughly east-west across the northern edge of a ~30,000 m² natural ledge that extends from the otherwise steep northeastern slopes. Boulder to cobble sized fragments of the flow are exposed at several locations today, and given the rapid soil development in these forested environments, exposures may have been larger in the past. South of the exposures is the GsJj50 archaeological quarry site, centered at S0°38'05", E36°15'21", at an altitude of 2604 meters above sea level.

Today, the area consists largely of agricultural fields with intermittent patches of mixed forest and montane bush. There are also large strands of Eucalyptus, indicating previous burning and re-planting episodes have shaped the current ecology. Before agricultural activity and modern settlement, and given relatively wet conditions after 3000 BP (Ambrose and DeNiro 1987), the Mau forest likely extended much further down Eburru Hill. It is likely that the quarry site sat at

least at the edge of the high canopy closed forest, if not within it. There are several steam vents and ochre sources around the site, the closest being a small cluster of vents roughly 150m to the southwest of the center of the quarry (see Zipkin et al. 2017). Very small single vents dot the ledge further south, with very large steam vent exposures existing further downslope. Ochre sources dot the upper slopes of Eburru in several other locations.

Located on the upper slopes of Mt. Eburru, the quarry is more difficult to access than the numerous obsidian sources in the southern Rift Valley, or even the other sources of green obsidian around the base of the mountain (Brown et al. 2013). There is no single approach to the quarry area today, nor was there in the past, although the eastern side of *Opuru* is the most gradual climb to the upper slopes and quarry locale. Ancient herders approaching the Elmenteitan Obsidian Quarry from most directions requires passing by, or through, the ochreous steam vent systems. These features may have made it easier to locate the obsidian exposures, however, and soil isotope data suggests that forests had retreated above 2600m in the Mid-Holocene (Ambrose and Sikes 1991). Accessing the site today requires taking the main road that branches from the Moi Lake Road near the base of Eburru, through Eburru Town. Keeping northward on the path leading over the mountain toward Lake Nakuru, large obsidian exposures are easily visible.

The site lies in a commanding and distinctive position, which raises questions about the role of phenomenology in the Elmenteitan preference for obsidians from this particular source group. It is possible, from various points across the site, to see across the northern Rift Valley to Lakes Elmenteita and Nakuru, and to the south across Lake Naivasha (see Figure 4.2). Given Mt. Eburru's position as an "intrusion" of the Mau escarpment into the Rift, the location of GsJj50 offers perhaps one of the most tactically advantageous views of the southern Central Rift system possible. Mt. Eburru is also, itself, a prominent phenomenological feature on the landscape.

Though most of the mountain itself blurs into the profile of the Mau Escarpment, the large basaltic bluff that sticks up from Eburru Hill is easily identifiable from at least as far as Lakes Elmenteita and Nakuru to the north, and southern Naivasha to the south (see Figure 4.3).

Foundational archaeological research in southern Kenya demonstrate the cultural coherence of the Elmenteitan group, the role of obsidians from upper Mt. Eburru for that group, and also the role of GsJj50 as the primary Elmenteitan quarry site for that obsidian (Ambrose 1980, 2001; C. Nelson 1980; Robertshaw 1988). Situating the quarry within its regional, and cultural, importance for Elmenteitan group led to several major questions regarding possible social control and access to the quarry (Ambrose 2001; Robertshaw 1988; Simons 2005).

Figure 4.2. (A) View looking south over Lake Naivasha from near the peak of Eburru Hill and (B) view looking north-east over Lake Elmenteita from the Elmenteitan Obsidian Quarry.

Figure 4.3. View of Mt. Eburru from Elmenteita (near Gilgil). GsJj50 is located near the peak of "Eburru Hill".

Figure 4.4. Obsidian exposure on Mt. Eburru.

Chapter 5

MATERIALS AND METHODS

5.1 Surveys

5.1.1 Survey design and strategy

I began the archaeological investigation of the Elmenteitan Obsidian Quarry with a survey project of the broader region with a set of nested goals. The first goal was to broadly characterize patterns of Holocene quarry use within the Central Rift Valley in order to target viable sites for future excavations. On the upper slopes of Mt. Eburru itself, surveys were oriented to locate previously unrecorded Pastoral Neolithic period quarries or other sites that may be related to quarry access and use. On the site-specific scale, I conducted walking surveys and GPS assisted mapping to assess and describe internal spatial patterns and distribution of obsidian exposures and features related to quarrying.

In most areas it was not practically possible, or within the scope of the survey goals, to carry out full coverage surveys (*sensu* Fish and Kowalewski 1990). On the upper slopes of Mount Eburru, the major impediments to survey were largely related to modern property boundaries, topography, and in some places dense thorn-bush or forest groundcover. As a result surveys outside of the boundaries of GsJj50 were either targeted to specific landscape features, or were opportunistic.

Conditions on Eburru are not ideal for conducting traditional surveys due to the aforementioned issues. In addition to topography and sometimes thick vegetation, it is clear that colluvial sediment deposition and soil development would have rapidly buried archaeological sites along the upper slopes. I therefore focused on surveying roadcuts, modern agricultural fields, and erosional features where buried archaeological sites were more likely to be exposed. Surveys of

the upper slopes of Mt. Eburru centered on the GsJj50 quarry site included with an area of approximately 6 km². I surveyed 1.5 sq. km of that extent with walking transects. Given the often difficult terrain and landcover, all spatial mapping and recording was done using a Garmin handheld GPS device. There was very little archaeological material overall, and generally we relied on the relatively high visibility of black and reflective obsidian debris to locate archaeological exposures. In addition I surveyed in the immediate vicinity of other major obsidian exposures on Eburru (documented by Brown et al. 2013). As these did not yield evidence of archaeological exploitation, I chose not to conduct systematic transect surveys in these locations.

It was only possible to use transect survey methods in a few areas where local topography permitted and landowner permission could be obtained (see Figure 5.1:B). Transect surveys were conducted over the core of the site itself, a large low-sloped open area to the northeast of the site, across a large clearing at the boundary of the modern Eburru Forest, and a low sloped 1.2 km² ledge that extends from the otherwise steep mid-eastern slope of Mt. Eburru. These areas with high ground visibility, matched criteria for pastoralist settlement preferences of well drained gradual sloped hillsides (see Ambrose 2001). I was also unable to survey areas near KenGen geothermal construction projects.

Survey teams in these areas included 2-5 individuals spaced 15 meters apart simultaneously walking east-west transects. The team included J. M. Munyiri of the National Museums of Kenya, and other highly trained archaeological fieldworkers, with the assistance of a student from the Eburru Secondary School. This degree of survey intensity makes it unlikely that sites larger than 0.1 hectare would have been missed. Although a few smaller scatters were encountered, it is possible that other small sites were not detected. A handheld Garmin global positioning system unit, digital cameras, and notebooks, were used in the process of identifying and recording lithic

scatters and obsidian exposures. Major points of reference and datum points were recorded using point-averaging GPS functions and are accurate to within 50 cm.

All coordinates were recorded using latitude and longitude mapped with the Universal Transversal Mercator (UTM) WGS1984 coordinate projection in Zone 37S. When artifact scatters were identified, a center point was taken and the diameter of the site was roughly approximated. As discussed in a Chapter 6, no significant sites were found that would require more extensive mapping or designation with a new SASES site designation. Photographs of ceramics and diagnostic lithics were taken, but no material was collected from surficial scatters on Mt. Eburru.

5.1.2 Mount Eburru surveys

Figure 5.1. Map details of 2014 fieldwork at the Oporu Quarry Site (GsJj50); (A) Satellite imagery of Ol Doinyo Oporu; (B) Pedestrian survey areas around GsJj50. Imagery from Google Earth Pro (after Goldstein and Munyiri 2017).

Targeted surveys of known caves and rock shelters in the dense Eburru Forest Reserve known to locals were undertaken with the generous assistance of Mr. John Kimani from the Eburru community, and Mr. David Terer and Mr. Patrick Kiita of the Kenya Forest Service. Together, we walked a single ~3.5 km circuit through the high altitude forest, and examined two small rockshelters and one rockshelter with a small cave that was about 5m in diameter. Mr. Kiita, who

identified as an Okiot (of the former hunter-gatherer Okiek community) and who grew up on Eburru, asserted that these are the three closest caves to the GsJj50 site within the forest boundary. Other, larger, caves exist further into the forest system, and many caves are known on the lower slopes of the mountain. Caves and rockshelter along the lower southern slopes of Mt. Eburru are also known to have rich LSA and MSA archaeological deposits (Slater 2016).

Figure 5.2. Cave and rockshelter transect survey within the Eburru Forest Reserve area. (Left) Showing circular transect in relation from GsJj50; (Right) Close-up of walking forest transect mapped with Garmin GPS unit, with rockshelter locations marked with stars. Imagery obtained through Google Earth Pro.

5.1.3 Site survey and mapping

Systematic mapping was carried out at the quarry site itself. The first goal of site mapping was to locate approximate site boundaries to determine the total area that had been used by prehistoric peoples. The second goal was to identify spatial variability within the extent of the site. I aimed specifically to target areas with in-situ deposits for archaeological excavation, and to map the location of obsidian exposures, quarrying or mining locations, spoil piles, and other reduction areas. Large accumulations of material on the surface had been upturned by agricultural activity

that consisted of planting corn and potatoes, using only hoes and other hand tools for tilling. The depth of disturbance typically did not exceed 30 cm from the surface. The abundance of obsidian debris across the surface of the site made it impossible to plot individual artifacts, or even scatters. Instead, I chose to take GPS points around areas where there was a significantly higher density of material on the surface upturned by crop harvesting by hand within the preceding week. I did include several large piles of obsidian debris that were overgrown by vegetation, but visible on the surface with the noted caveat that they could very well be from historic land clearance. The map generated from these points is presented in Figure 5.3.

5.2 Archaeological excavations

In the summer of 2014 I undertook formal mapping and excavation of the Elmenteitan Quarry Site (GsJj50) on Mt. Eburru. The goals of the archaeological project were to (1) identify intra-site activity areas related to obsidian quarrying and core preparation, (2) recover archaeological materials, especially lithic cores, tools, and blade debris, associated with use of the site and (3) assess formation processes and taphonomic forces that could have affected preservation or distribution of archaeological remains.

5.2.1 Excavation areas

I used the UTM (WGS1984, Zone 37S) coordinates of the northeast corner of each 1x1 meter of excavation to name the units during fieldwork. Each unit was also given a shorthand numerical designation (e.g. Unit 1, Unit 2, Unit 3). I excavated a total of 11 m².

Figure 5.3. Location and topography of the Elmenteitan Obsidian Quarry (GsJj50) with modern and archaeological features marked.

I chose the location of each unit based on the presence of archaeological materials in adjacent roadcuts, upturned surface material in the modern agricultural terraces, proximity to visible features, and to explore patterns detected in previous units. The site was divided into three “areas” due to difference in land-cover and use, and the apparent variation in archaeological signatures as visible during initial mapping. I placed excavation units in all three areas in order to investigate whether excavations would differences in stratified deposits across the site. These areas were:

Area 1. The primary excavation area lay within a modern agricultural terrace (Figure 5.4). Units were placed in locations where there was little material on the surface, but near road cuts with dense archaeological layers were exposed. I excavated two 1x2 m trenches, and four 1x1 m

unit (Figure 5.6). One of these units was used as a geological test trench aimed at identifying any earlier occupational episodes and to correlate the archaeological sequence on-site with geological exposures visible elsewhere in the area. In addition to the excavation units, 10 shovel test pits were placed in a cruciform pattern extending north-south and east-west and centered just to the south of the 1x2m trenches. These were placed in order to detect the extent of the activity areas as it became clear that they were not a continuous horizon.

Figure 5.4. Excavation Area 1- terraced agricultural field. Note Area 3 is located in the forested area in background. Photo taken facing west.

Area 2. I placed a single 1x1 m unit within a patch of forest, directly adjacent to large exposures of an *in situ* outcrop of obsidian and extremely dense exposures of lithic material visible in the nearby roadcut (Figure 5.5). Here, we encountered a buried archaeological horizon in the form a 50 cm thick layer composed almost entirely of obsidian quarrying and core reduction debris. Profile cleaning along the adjacent road cut and near recent construction activities allowed us to

map the approximate extent of quarry debris without further excavation of these extremely dense deposits.

Figure 5.5. Excavation Area 2. Photo taken facing north.

Area 3. On a steep hill overlooking the site we located several rock-pile features resembling cairns and a few large obsidian blade cores on the surface. I chose to excavate two 1x1 m units in this area; one bisecting a rock-pile, and other located 3 m to the west. These features were clearly anthropogenic, but archaeological material was rare both within and around, them. According to local oral history, this area was the location of a seasonal Okiek camp in the early 20th century. Only one microlithic fragment, one flake fragment, and one fragment of bottle glass were collected from excavations in this area.

Figure 5.6. Map details of 2014 fieldwork at the Oporu Quarry Site (GsJj50); (C) Excavation units in relation to modern land features; (D) Approximated reconstruction of activity areas at GsJj50 using data from excavations, shovel test pits, road-cut profiles, erosional features.

5.2.2 Excavation procedures and data collection

Natural layers were followed when possible, however there were no significant changes in the matrix within the archaeological horizon to merit subdivision. I chose to excavate the archaeological deposits in arbitrary 5 cm spits. The overlaying plow-zone and underlying B-horizon sediments were easily distinguished from the darker organically enriched archaeological horizon and were largely sterile and were excavated in 10 cm spits. After reaching 10-20 cm below the archaeological horizon and once a sterile B horizon was identified underlying the archaeological horizon in the test trench, excavation units were closed.

Following methods for recording horizontal provenience used at other large Pastoral Neolithic sites like Ngamuriak, Gogo Falls, and Prolonged Drift where high densities of material prevent piece-plotting (Gifford et al. 1980; Robertshaw 1990, 1991), I subdivided each square meter into quadrants for provenience. During excavation of Unit 1 it became clear that lithic debris was distributed along relatively discrete surfaces and/or “piles” that overlapped. While the

separation was not visible in the stratigraphy, it was apparent when excavation was slowed to carefully reveal each lens in succession.

In keeping with the collection strategies referenced above and those used at other ongoing Pastoral Neolithic projects (see Hildebrand et al. 2009; Prendergast et al. 2011), each horizontal quarter-meter of each 5-10 cm spit constituted a unique “context”. Therefore the context is the basic unit of provenience with specific tri-dimensional spatial parameters. Features were only present in the form of the cairns in Area 3, and in this case all material from within the features likely constituted a single deposition event and thus was recorded as a single context regardless of quadrants or depth. Material outside of a feature was, accordingly, a separate context. I assigned each class of material culture and biological remains (e.g. lithics, ceramics, fauna, ochre) from each context a unique bag number for collection and sorting. Each physical bag was labeled with the site SASES code, the UTM coordinates of the excavation unit, bag number, spit, quadrant, material type, date, and excavator initials.

A major goal of excavations was to reveal the distribution of archaeological materials before collecting artifacts. Artifact clusters were photographed at multiple angles for later photogrammetric modeling to document the size, shape, and orientation, of artifacts in three-dimensional space. After documentation, we collected visible material over ~2 cm in size and screened 100% of the matrix from all contexts through 5 mm mesh, except for one litre sediment samples reserved for flotation analysis. All material from shovel test pits was also screened. When possible, charcoal samples were collected directly from excavations using spoons without being handled. In Area 1 and Area 3 we were able to collect 100% of artifacts. The quarry deposits in Area 2 were so dense that this was not possible, and the material was field sorted with large angular

debris without evidence of flaking separated, weighed, and recorded in bulk per quarter meter context, but not ultimately collected (see example in Figure 5.7).

Figure 5.7. Example of un-collected angular obsidian waste from a single 25cm x 25cm x 5cm context in Area 3.

I used a consistent note-keeping format for all record keeping during excavations of each spit. Notes for each spit included date excavated, provenience, sediment and soil descriptions (grain size, inclusion type, morphology, and density, Munsell color), a catalog of all bag numbers within that spit, photo descriptions, archaeological materials, and any other relevant notes or descriptions. Notes were accompanied by plan drawings of each spit along with its starting and ending depths for all four corners and the unit center. Other procedures including taking opening and closing photos of each spit, and taking photos of artifact clusters and other features. At the close of each excavation unit I measured and drew the stratigraphy of all four walls. Each geological layer was assigned a three-letter code in keeping with excavation procedures in eastern Africa.

Analysis included all artifacts and ecofacts recovered from the Elmenteitan Obsidian Quarry, and comparative lithic sample from several other Elmenteitan sites (Chapter 7). All materials from excavations were brought back to the National Museums of Kenya, Nairobi, for washing, cataloging, analysis, and final curation. There, material was washed and sorted. Lithic artifacts were sorted by raw material, organized and re-bagged by type and organized in the following order: (1) Groundstone, abraders, hammerstones etc. (2) cores and core fragments, (3) platform removals and core trimming elements, (4) microlithic pieces, (5) scrapers, (6) awls, percoirs, notches and other shaped tools, (7) splintered pieces, (8) informally retouched and utilized pieces, (9) complete blades, (10) complete flakes, (11) proximal flake fragments, (12) medial flake fragments, (13) distal flake debries, (14) flake shatter, (15) angular waste.

All contextual information was transcribed onto the new bags, and a card with the same information, as well as the type, count, and weight of materials was each bag was placed within each bag. The following sections describe all analytical methods and measurements for each artifact class.

5.3 Lithic attribute analysis

5.3.1 Obsidian quality

It became apparent during excavations that there was considerable variation in the quality of obsidian debris within quarry site deposits. I developed a qualitative rating system for recording quality in order to capture this variability. The primary criteria are the number of flaws, inclusions, or impurities, opacity/transparency, and texture. These refer only to internal obsidian quality, and does not refer to external cortex. Each artifact received a rating from “1”, or pure glass, to “8”, which had an extremely porous texture resembling scoria (see below). For practical intra-site and

comparative analysis, I grouped these into “high quality”, “medium quality”, and “low quality”. In some cases the ventral and dorsal sides of a flake were markedly different, in others proximal and distal ends had different obsidian qualities. In these instances I recorded both applicable quality measurements.

High Quality: (1) Pure glass, no inclusions or flaws; (2) Pure but slightly opaque glass, slightly waxy texture

Medium Quality: (3) Waxy opaque with some flaws or inclusions; (3b) semi-grainy opaque glass <33% grain; (4) Grainy texture 33<x<66%; (4b) opaque coloration or striation of granular bands

Low Quality: (5) >66% granular texture, or heavily banded with large inclusions; (5b) dacite like, but hard to distinguish flake features; (6) Slightly porous scoria-like texture but flake morphology still visible; (7) large bubbles or very porous, flake morphologies very difficult to see; (8) completely porous resembling scoria, only fragments or granules, no flake features visible.

5.3.2 Cores

I developed a nested classification scheme for core typology. First, cores were described by the form of flake scars visible (i.e. the type of blank produced from the core), which could include flakes, blades (flakes at least 2 times as long as they are wide), or bipolar. Next, they were sub-categorized by the orientation of striking platforms. The platform orientations present in the assemblage include parallel (one striking platform with serial reductions), opposed (two platforms on a face oriented parallel to each other), rotated (two platforms oriented at 90 degrees to one another), radial/discoidal, or multiple-platform. Bipolar cores were designated as being either normal bipolar cores, or splintered pieces (following Shott 1999). The latter category tentatively includes what are elsewhere called *outils à caillès*, scalar pieces, and *batonnetes*, as recent experimental research demonstrates they are likely derived from the bipolar reduction of blade segments (de le Peña 2011).

Figure 5.8. Flake scar orientation for different types of cores defined here.

I also recorded several technological traits that are relevant to nodule selection and reduction strategy. When possible, I noted the form of the blank selected for flaking as being a natural nodule, an angular obsidian fragment, or a large flake. A second important attribute was the orientation of striking platforms relative to core geometry. In many cases this overlaps with core “shape”. Here, I refer only to the strategy with which a cores surface area was exploited by flaking. Formal cores might be described pyramidal, cylindrical, or navi-form. Less intensively prepared, or informally flaked, cores could have only a single or two reduction “faces”, exploiting only a small amount of a nodules surface area.

Quantitative measurements also aid in assessing core shape and reduction strategy. I recorded the total number of platforms, number of visible flake scars, skew of flake scars relative to core surface, number of step or hinge fractures visible, the total length of the prepared striking platform, and the length of the striking platform that was exploited for flaking, and cortical surface area (after Lin et al. 2010; Pelcin 1997). Core height was recorded as the longest dimension of a

core parallel with a flake scar. Relative to this measure, I also recorded core width and thickness, allowing for rough volume estimates. Core weight, a proxy for raw material utility, was recorded in grams. These measures were accompanied by any relevant descriptive notes or observations. While core morphometrics and scar density are useful tools for evaluating core reduction strategies (see Bretzke and Conard 2012; Clarkson et al. 2006; Lin et al. 2010; Lycett et al. 2010), there were too few large cores recovered from the excavations at GsJj50, and in general too few large cores for any comparative sites for meaningful analyses.

5.3.3 Tools

Tool typologies and variation in formal tool morphologies are important for understanding site function (Binford 1979; Goodyear 1993; M. Nelson 1991) and placing assemblages within regional assemblage groups (Ambrose 2001; Phillipson 1976). Definitions for tool types and the typological scheme used to describe the GsJj50 assemblage follow those developed by Ambrose (1980, 1998) and C. Nelson (1973, 1980) for East African lithic assemblages. Formal tools, retouched implements with an imposed morphology, with differentiated expediently retouched and utilized pieces. Lengths, widths, thicknesses, and weights for all tools were recorded, as were individual tool features like notch size and scraper working edge lengths. I also recorded the dorsal and ventral location of utilization and/or retouch following Clarkson (2002). The major groups of lithic tools present in the GsJj50 assemblage include microliths, scrapers, borers, burins, notches, and combination tools.

Microliths: Small backed flakes or bladelets, typically not exceeding 3 cm (Robertshaw 1990: 82). Microliths backed on multiple edges or angles to form a triangular, crescentic, or trapezoidal shape are classified as “geometrics”. Backing along one margin that is oblique,

orthogonal, or perpendicular to the flake length axis constitute “truncations”, and pieces with backing parallel to the flake axis are defined as “straight backed”. This category may also include various micro-percoirs depending on size and morphology (C. Nelson 1973).

Scrapers: These are pieces with semi-abrupt to abrupt unifacial retouch. The main variants are endscrapers, where the working edge is perpendicular to the flake length axis forming a truncation, and sidescrapers where the working edge is along a lateral side of the flake. Scraper working edges are typically convex, however some have notch-like concave retouched edges. Number of working edges, the steepness of working edges, and other morphological specifics constitute subdivision into “steep battered scrapers, nosed scrapers, convergent side-scrapers, and informal scrapers”. In this assemblage I also define “inverse” scrapers, wherein the retouch originates along the dorsal side and terminates on the ventral face, which is the opposite of typical scraper retouch morphology.

Borers: This category includes reamers and percoirs, but may also include non-microlithic awls. Percoirs are defined as tools with a sharp point formed by retouched edges that come together at an angle less than 90 degrees, whereas reamers’ retouched edges form an angle of over 90 degrees (Robertshaw 1990: 85). Similar pointed features formed by retouching opportunistic spurs on a flake are labeled as “becs”, and are a type of informal tool.

Burins: Burins feature a flat working edge produced by removing the sharp edge of flake laterally. The distinctive flake removed is a burin spall, and typically has a triangular or polygonal cross section. Common variants include, but are not limited to, burin plân (see C. Nelson 1980; Ambrose 1985), and dihedral burins where one burin blow is used as a platform for another, or a sequence, of opposed burin removals.

Notches: These are blades or flakes with deep convexities formed by intentional retouch and/or utilization. Pieces may have several notches, and pieces with more than three minor serial notches are included under the subgroup “denticulates”.

Combination tools: This includes pieces with any of the above shaped tool morphologies, along with additional retouched features. Combination tools can include the attributes of two formal tools (e.g. combination scraper and burin), or simply be a formal tool with discrete retouch or trimming. Tool transforms are implements that have been retouched from one tool form to another through their use-life.

5.5 Debitage technological analyses

5.5.1 Attributes and terminology

Unretoucheddebitage can be classified based on morphology and position within the process of core reduction. Here, the term “blade” refers to any complete flake that is at least twice as long as it is wide and/or has lamellar or prismatic flake scar patterns. This terminology allows partialdebitage to be labeled blade segments following the typology in Ambrose (1985) and Slater (2016). Due to the nature of the site as a specialized quarry it is especially useful to definedebitage related to core preparation and modification. In addition to the standard categories of platform removal flakes, core tablets, I used the category of “preparation flakes” to denote removals that removed cortical material and shaped nodules into cores, and “initial blades” (see Andrefsky 2005: 146). Additional attributes for each flake include the following variables when applicable;

Flake metrics: Length, width, thickness, weight following Andrefsky (2005: 98-102).

Cortex: An estimate of the percentage of the dorsal flake surface that retains exterior weathered surface made to the nearest 10% interval (See Andrefsky 2005: 106).

Scar pattern: The directionality of flake scars on the dorsal surface following the same terminology as this attribute for cores. This variable reflects core morphology and orientation of striking patterns (Baumler 1988).

Scar count: The total number of visible major flake scars retained on the dorsal surface as a rough correlate for stage of production and core morphology (Gilreath 1984:3; Johnson 1987:193; Lyons 1994: 33; Magne and Pokotylo 1981).

Flake symmetry: Curvature of the flake in plan view as determined by the angle with which the distal end of the flake deviates from the vertical axis of the striking platform. Flakes can have left, right, or straight symmetry. Flakes with left or right symmetry are further classified in terms of whether the amount of planar curves is under or over approximately 30 degrees. This is good indicator of blade core shape with cylindrical and pyramidal cores being more likely to produce straight blades.

Dorsal features count: The total number of step or hinge fractures retained on the dorsal surface of the flake, their direction of propagation.

Termination: The morphology of the distal end of complete blades. Natural terminations may be feather, hinged, stepped, or plunging. Elmenteitan tool production heavily involved blade segmentation and snapping (C. Nelson 1980; Ambrose 1984a). When intentional segmentation was apparent, this was recorded in place of termination, though these specimens would not be considered “complete” for the purposes of analysis.

Blade curvature: The overall curvature of the blade in the Z axis. Following Andrefsky (1986) curvature was calculated relative to the total length of the flake using midpoint thickness and angle height. This is a proximate measure that assumes continuous curvature, and therefore may misrepresent blades that are flat except for a sharp distal curvature around the bottom of a

core. I chose to record these rare instances as being essentially straight to avoid conflation with actual core face curvature. Despite the weaknesses of this particular method, curvature remains useful for discussing core design (Andrefsky 2005; Bretzke and Conard 2012; Gilreath 1984).

Bulb damage: This was recorded as a presence/ absence of production damage to the bulb of percussion in the form of shattering or, more commonly, the shearing off of the bulb due to a mis-application of force during punch method blade removal. These features are essentially very large step terminating erailleur scars. I also recorded any occurrences of double or triple bulbs of percussion.

5.5.2 Platform measurements and morphologies

The size, morphology, and form of preparation of striking platforms are recognized as important technological traits within Pastoral Neolithic assemblages (Ambrose 2002). Platform attributes at the Elmenteitan Obsidian Quarry can, therefore, be useful for contextualizing the site and understanding its relationship to other Elmenteitan occurrences. Debitage was first classified into one of three groupings: (1) Blades; (2) flakes; (3) core preparation debris, including platform removals or alterations, large removals of cortex, or removals of large portions of the core face. Each category has different expectations for platform type and size. Within these categories, all intact platforms not modified by later retouch were classified following definitions developed by Ambrose (1980, 2001) and Andrefsky (2005: 96). The primary classifications for platforms were unprepared (plain, chapeau de gendarme, cortical) and prepared (abraded with dorsal-proximal faceting [DPF] (Slater 2016), regular faceted, and micro-faceted). Noting significant variation with the intensity of platform preparation, it was necessary to define if abrasion covered the entire platform or was restricted to the edge, leaving much of the platform unprepared.

5.5.3 Quantifying production strategies

The primary goal of analyzing the lithic assemblage from GsJj50 was to determine the variability present within Elmenteitan blade core production strategies within a quarry environment. This data is important for understanding whether or not a single group, or multiple groups, were engaged in quarrying. Models for core reduction can be best developed through an approach that anchors a *chaîne opératoire*, or “operational sequence”, descriptive analysis with a quantifications of core morphologies and reduction strategies (see Audouze 1999; Bleed 2001; Geneste 1985; Sellet 1993; and review in Shott 2003).

Given the lack of cores in the assemblage, I will use the blade attributes and measurements discussed above as proxy measures for the design of the parent cores. In other words, blade attributes will be used to assess design at various states in the reduction sequence. Analysis will include a combination of uni-variate, bi-variate, and multi-variate approaches using the blade measurements and attributes discussed above. Table 5.1 lists the variables that will be most important in understanding reduction strategies.

As a core is reduced, the maximum length of blades will decrease. The rate at which length diminishes is highly dependent on core design and maintenance, but reduction is inevitable. Blade length is therefore a useful dependent variable proxy for stage of core reduction is the most important axis of core design for analytical purposes. All relevant variables (i.e. cortex, platform area, curvature, symmetry, flake scar directionality, flake scar count) must be assessed relative to the blade length to understand how core shape changes through reduction. All else being equal, there should be continuous changes as blade (i.e. core) size decreases unless shape is being maintained or modified intentionally (Andrefsky 2005; Lengyel and Chu 2016).

Table 5.1. Attributes recorded for blade debitage and their analytical applications. .

Attribute	Variable	Definition	Application
Length	Interval	Maximum dimension measured perpendicular to the width of the striking platform.	Core reduction strategy, core design, skill and learning
Width	Interval	Maximum dimension measured perpendicular to the length along the body of the flake,	
Thickness	Interval	Maximum dimension between the dorsal and ventral faces of the flake.	
Weight	Interval		Core reduction strategy
Platform width	Interval	Maximum horizontal dimension of the striking platform	Core reduction strategy, skill and learning
Platform thickness	Interval	Maximum vertical dimension of the striking platform	
Platform type	Nominal	Shape and method of platform preparation	Skill and learning
Termination	Nominal	Morphology of unbroken distal end of the flake	Skill and learning
Cortex	Ratio	Percent of the dorsal surface covered by cortex (estimated)	Core reduction strategy, core design, nodule selection
Scar count	Interval	Number of major flake scars visible on the dorsal surface of the flake	Core reduction strategy
Scar orientation	Nominal	Directionality of flake scars	Core reduction strategy, core design
Curvature	Ratio (0-90)	Curvature of flake in the z plane	Core design
Symmetry	Nominal	Skew of flake in the x-y plane relative to platform axis	
Bulb of percussion	Binary	Presence/absence of bulbar shearing	Skill and learning
Dorsal errors	Ordinal	Count and direction of hinge and step terminations on the dorsal surface	
Material quality	Ordinal	Rating of internal obsidian quality	Nodule selection, core reduction strategy

Changes in another variables through reduction will similarly highlight the aspects of core morphology that are prioritized and the range of variability in core designs present. Considering that this is a quarry site where knappers had their pick of obsidian nodules of different qualities,

the null expectation is that most of the variability will be found amongst the longest blades, which represent the earliest stages of preparing a nodule. As cores approach an intended shape and size, all blade products should demonstrate a more uniform set of metrics and attributes.

Analysis of all uni-variate and bi-variate relationships is conducted on the blade assemblage as an aggregate unit, unless stratigraphic or spatial patterns justify subdivision. Analyses based on these variables are used to determine which of the following two possibilities is best supported for GsJj50:

- 1) Blade debris overall demonstrates a consistent pattern of core design, suggesting a single “tradition”, and likely a single group, carrying out core reduction.
- 2) Blade debris reflects highly variable patterns of core design, and there is no “preferred” Elmenteitan style. This would suggest that multiple groups were engaged in quarrying and workshopping.

5.5.4 Production mistakes and errors

In order to evaluate the possibility of learning and hypotheses regarding the nature of communities of practice (CoP’s) surrounding quarry use, I quantified the error rates for the sampled assemblages. I created a list of measurable attributes related to both “high skill” and “low skill” blade reduction following criteria established through the archaeological and experimental projects of Bamforth and Finlay (2008), Ferguson (2003), Eren et al. (2011), Lassen and Williams (2015), Milne (2012), and Tostevin (2013). These are presented in Table 5.2, and include several traditional “mistakes”, including double bulbs of percussion, step and hinge terminations, dorsal steps or hinges, high curvature. Using these guidelines, I selected several specific measurements or attributes that could be used to assign specific error scores to each individual blade. Assessing

skill by using full reduction and re-fit sequences is ideal, however these are lacking at Pastoral Neolithic sites, and so I used this strategy based on scoring error rates and assessing error rate averages in an assemblage.

Additional criteria were added to account for the specific nature of Elmenteitan blade industries based on the following assumptions: (1) Blade production is intended to produce blanks of consistent size and shape; (2) blades with length:width or length:thickness ratios that are too high or low would be undesirable; (3) while mistakes are inevitable, repeated mistakes are a sign of novices and corrected mistakes are a sign of experts; (4) over and under prepared platforms are a sign of novices. These criteria can be revisited and reevaluated as continued analysis of Elmenteitan and PN technologies refines our understanding of production goals and *chaîne opératoire*.

The score for each blade is cumulative for all errors. Flakes that successfully removed previous dorsal steps or hinges, from an opposed end, from the same platform, or from a right angle to the platform indicate a skilled correction of a mistake and were given a score of (-1) accordingly (Table 5.3). Error rates were calculated as the average error score of all complete blades in the assemblage. Assemblages with very small sample sizes were not included. The Suswa Lava Tubes sample was also discluded as it was a surface collection. Sites with high relative average error scores are those where lithic learning processes may have contributed more to the archaeological assemblage.

Table 5.2. Characteristics of skilled and unskilled knapping in blade-based lithic assemblages. Modified from Bamforth and Finlay (2008), Tables I and II.

Indicators of high levels of skill	Indicators of unskilled knapping
Very large blade size	Irregularity in form
Very low thickness-to-width ratio	Predictable errors
Extreme length relative to width or thickness	Stacked step and hinge terminations
Regularity of form	Inconsistency in production
Plan-view symmetry	Plan-view asymmetry
Very small platform-to-size ratio	Low length-to-width or –thickness ratio
Complex, patterned, multi-stage reduction strategies	Deviation from expected <i>chaine opératoire</i>
Maintenance of core shape through reduction	Peripheral knapping location
	Failure to maintain, properly prepare, or rejuvenate platforms
	Over-prepared platforms

Table 5.3. Criteria for scoring error rates on Elmenteitan blades.

Variable	Criteria	Error value per blade
Production errors	hinge or step terminations, dorsal evidence for previous hinge and step terminations, shattered platforms	1 for single errors 2 for 2-5 errors, compounded step fractures 3 for >5 errors -1 for evidence of corrected errors
Blade asymmetry	lateral skew >60 degrees significant blade twist curvature over 2 sd from mean.	1
Size/shape	length:width or length:thickness ratio over/under 2 sd from mean.	1
Platform preparation	unprepared or overprepared platform	1

5.6 Ceramic analysis

Ceramic sherds were identified following regional typologies (Collett and Robertshaw 1983; Wandiba 1980; see also Ambrose 1984b, Bower et al. 1977). Features like decorations, rims, lugs, spouts, bases, etc. were noted if and when they occurred. I measured the largest dimension, maximum thickness, weight, and any inclusions or temper visible within the matrix of each sherd. Given the possible regional variation in color between the typically darker “Remnant ware” and the lighter Elmenteitan ceramics known from the Lemek Valley (see Ambrose 1982; Bower et al. 1977; Robertshaw 1990), I recorded interior and exterior colorations for each sherd using a Munsell Color Guide. Also using the Munsell Guide as a reference, I estimated the size of inclusions, and the density of those inclusions across the sherd. All decorated sherds and a representative sample of undecorated sherds were photographed.

I used a ceramic profile gauge to extrapolate total rim diameter measurements from each rim sherd. In addition, each rim sherd was illustrated on graph paper and inked in Adobe Illustrator. Where possible, I assigned rim sherds to one of the general Elmenteitan vessel morphologies described by Robertshaw (1990) and Collett and Robertshaw (1983) using a combination of rim form, sherd thickness, and rim diameter estimates.

5.7 Faunal analysis

Potentially identifiable faunal material was separated from non-identifiable material and sorted according to element and taxonomy using comparative specimens in the National Museums of Kenya for reference. When possible, non-identifiable mammal bones were assigned to size

category following Gifford et al. (1980). Assessments of fragmentation followed the scale developed by Bunn (1983) and weathering stages were recorded following the scale developed by Behrensmeyer (1978). No whole tooth rows were recovered, however it was possible to approximate wear stages for individual teeth using descriptions from Marshall (1990: 207). Modification in the form of cut marks and burning was recorded and described when they occurred (following Shipman et al. 1984; Lyman 1994; Reitz and Wing 2008: 132).

5.8 Radiocarbon dating

One sample of charcoal from the top, middle, and bottom of the archaeological horizon were chosen for AMS radiocarbon dating. These samples were submitted to Woods Hole Oceanographic Institute in Woods Hole, MA, USA. The resulting dates were calibrated using OxCal v.4.2, SHCAL13 southern hemisphere calibration (Bronk Ramsey 2009; Hogg et al. 2013).

5.9 Comparative analysis

5.9.1 Sampling

Choosing which Elmenteitan sites to sample requires a compromise between favoring larger samples with more statistical power, and a higher number of samples that better covered the total temporal and regional distribution of the Elmenteitan. I favored the latter option for this analysis given the relatively small number of total Elmenteitan sites known, and the very few existing analyses of regional variability (but see Ambrose 1980, 2001). Given time restrictions, I sampled 12 Elmenteitan assemblages housed in the National Museums of Kenya that cover as much of the Elmenteitan range as possible. These are Bromhead's Site, Enkapune Ya Muto,

Enkapune Ya Sauli, Gambles Cave II, Gogo Falls, Lion Hill Cave, Ngamuriak, Njoro River Cave, Olopilukunya, Remnant, Suswa Lava Tube (surface collection only), and Wadh Lang'o (see Table 5.4). For some analyses I have included the SPN sample of Narosura as an outgroup to help determine which measures offer meaningful insights into reduction strategies specific to the Elmenteitan.

Assemblage sizes are inherently different between sites, however these differences reflect combinations of site function, assemblage fragmentation, and extent of excavation. As the comparative analysis consists of multi-variate analyses with multiple variables, it was not practical (or indeed possible) to use a power analysis to determine ideal sample sizes. Sample sizes were inherently limited for many sites simply due to the small size of the collection. In these cases I included as many blades as possible. For much larger assemblages, I instead aimed to include between 50 and 60 blades selected by stratified random selection of context-specific bags.

Ideally only minimally retouched and complete blades were included in the analysis. Partial blades could have been included into the multi-variate analysis, however a missing proximal or distal end would require entering missing data for multiple variables. For example, a missing platform would mean not being able to enter length, curvature, platform preparation, and platform size for that piece. As a result, blades missing either proximal or distal ends were excluded. It was necessary to include pieces with lateral retouch and/or utilization (as long as modification did not appear to significantly impact width) in order to maximize sample sizes.

Sub-sampling is also problematic. Some assemblages are very small (~8 pieces), and random sub-sampling 8-10 pieces from larger (>50) assemblages may not generate a representative sample. It is more pragmatic instead to consider the data patterning of small assemblages to be inherently less reliable, and to use more caution in interpreting these sites. Obviously this is not

ideal, however it is important for exploring potential diversity in Elmenteitan lithic assemblages relative to the Elmenteitan Obsidian Quarry. Basic metrics for Ngamuriak, Olopilukunya, and Enkapune Ya Sauli were recorded in the Summer of 2011 and supplemented by additional measures in the Fall of 2014. All other sites were fully analyzed in the Fall of 2014.

5.9.2 Elmenteitan samples

All of the sampled sites are discussed in Chapter 2 (section 4) in terms of how they fit within the broader patterns of Elmenteitan settlement patterns, subsistence systems, and chronology. This section focuses on the excavations of these sites, their modern ecological and geographic context, and specific data on the blade samples used in this analysis.

Bromhead's Site (Elmenteita). Bromhead's site was first identified by Mr. Bromhead in 1917 during the course of construction on his property. It is located along the southern bank of the Makalia River along the southern edge of Lake Nakuru. The site proper consists of several small rock crevices which served as a burial ground and covered about 50-60 square meters. The site is variably reported as partially or heavily disturbed (Leakey 1927; Leakey 1935) with very little stratigraphy within the deposits. Louis Leakey visited the site in 1926, and noticing there were several exposed skeletons, undertook excavations the following year (Leakey 1935: 57). There are no reliable radiocarbon dates for the burials, however the lithic and ceramic assemblages are distinctly Elmenteitan. Despite the small assemblage and contextual problems, its unusual nature as a burial ground makes an interesting data point to compare with habitation sites as well as the Elmenteitan burial site at Njoro River Cave. Six complete blades from Bromhead's site were included in this analysis.

Enkapune Ya Muto. Enkapune Ya Muto is a 7 by 11 meter rockshelter site situated along the steep eastern slopes of the Mau Escarpment at 0°50'S, 36°09'E, 2400 meters above sea level. Excavations by Stanley Ambrose in 1982 revealed a deep sequence that extends from the Middle Stone Age to the Pastoral Iron Age (Ambrose 1984c; 1998). Elmenteitan strata dating to 2600 BP produced a dense lithic assemblage with wild and domesticated fauna (Ambrose 1984b, 1998). I sampled 41 complete blades from the lithic assemblage for comparative analysis.

Enkapune Ya Sauli. Enkapune Ya Sauli is a rockshelter site that lies within a steeply sloped gully along the eastern edge of the Mau Escarpment at an elevation of 2560 meters above sea level. It is due west of Lake Naivasha and about 10 km northwest of the well-known site of Enkapune Ya Muto. The rockshelter, excavated by Stanley Ambrose, measures 4.5 by 9.5 meters and has a main Elmenteitan occupational sequence dated to between 2040 and 1480 BP (Ambrose 1984b). The lithic and ceramic assemblage were diagnostically Elmenteitan, although there may be a very high frequency of wild animals relative to domesticates reflected in the fauna. I sampled 53 complete blades from the site.

Gamble's Cave II: The Gambles Cave site is located 11km southeast of Lake Elmenteita, at the western edge of Central Rift Valley. Gambles Cave overlooks the Nderit River that flows in a narrow valley about 60 m below the site, and is itself within a densely wooded valley before colonial settlement (Ambrose 1984b: 129). At an elevation of 1934 meters above sea level, it is typical of the low-elevation pattern of Elmenteitan rockshelter occupation in the Central Rift. Leakey (1931: 200) excavated a portion of the site between 1927 and 1929, and Glynn Isaac and Ron Clarke exposed a 1-2 m wide witness section to procure dates for early Holocene levels. The 8.5 meter deposit contains a sequence of Eburran phase III-Va materials. Elmenteitan material occurs in the upper portion of the rockshelter (Ambrose 1984b: 130). A higher resolution

chronology exists for the lower Eburran deposits, but the exact date of the Elmenteitan layer is less clear (Ambrose 1984b: 137; Fleischer et al. 1965). A total of 25 complete blades were sampled for this analysis.

Gogo Falls. Located on the eastern shores of Lake Victoria, Gogo Falls is the Elmenteitan occurrence furthest from the Mount Eburru quarry. It is a stratified multi-component site with significant Kansyore fisher-deposits underlying the Elmenteitan stratum, which in turn are overlaid with an Urewe stratum (Robertshaw 1991; Wandibba 1986). Significant excavations were carried out by Robertshaw and Karenga-Munene between 1983 and 1989 covering over 160 sq. m. (Robertshaw 1991). Layers with characteristic Elmenteitan lithics and ceramics, along with domesticated fauna, were dated to between 1992-1610 BP. A high ratio of fauna in the Elmenteitan horizon was originally attributed to zoonotic stresses in bush environments (see Marshall 1986; Gifford-Gonzalez 2000). More recent isotopic work by Chritz et al. (2015) suggests Gogo Falls was situated in a more open ecology on an isolated inselberg that supported open grasses. Other than the inclusion of wild fauna at the site, typical Elmenteitan patterns are maintained including the preference for Mt. Eburru obsidians. Obsidian likely derived from Mt. Eburru is the most dominant obsidian type (between 65-100%) in all Elmenteitan contexts across excavation areas (Robertshaw 1991: 87). The sample from Gogo Falls consists of 17 blades.

Lion Hill Cave (GrJi60): The Lion Hill Cave site is a small rockshelter situated just east of Lake Nakuru, excavated by Louis Leakey and colleagues (Leakey 1931; 247-8). At the time of excavation the site was situated in a primarily bush environment along a north-south ridge at 1934m above sea level. Like other caves and rockshelters in the region, there is a sequence of Eburran occupations through the early-mid Holocene with overlaying Elmenteitan levels (see Ambrose 1984b: 139-141). This ashy midden layer containing human burials was 20-150 cm

below surface and separated from the Eburran deposits by sterile layers. Lithics from the Elmenteitan horizon are technologically consistent with material from Bromhead's Site and Gamble's Cave, although with a higher proportion of tabular flake cores, crescents, and curved-backed pieces (Bower et al. 1977: 122). Overall, the upper lithic stratum is accepted as an Elmenteitan occurrence (Ambrose 1984c; C. Nelson 1980). Ten complete blades were sampled.

Ngamuriak. Ngamuriak is an exceptionally large Elmenteitan settlement site in the Lemek Valley along the Oldorotua River in the Loita-Mara region of southwestern Kenya. It was first identified in a large erosional feature that revealed an otherwise undisturbed 20-30 cm archaeological horizon. There were three seasons of excavation by Fiona Marshall and Peter Robertshaw between 1981 and 1985, covering roughly 1094 sq. m. (Robertshaw 1990: 54). Radiocarbon dates for the archaeological horizon largely cluster around 2000 BP. Excavations revealed several suspected dung deposits, middens, and a possible house-floor. Material culture was Elmenteitan, and faunal analysis by Marshall (1990) demonstrated that 99% of identifiable remains were domesticated, suggesting a highly specialized pastoral economy. A total of 22,738 lithic artifacts were recovered, and 85% of specimens analyzed during geo-chemical sourcing were identified as green obsidians sourced to Mt. Eburru (Merrick et al. 1990; Robertshaw 1990: 88). A total of 55 blades from Ngamuriak were sampled for comparative analysis.

Njoro River Cave. Excavated by Leakey and Leakey (1950), Njoro River Cave is a dense mortuary site located along the banks of the Njoro River, a few kilometers west of Lake Nakuru. The Leakeys excavated roughly 140 cubic meters of the outer rockshelter area to a depth of between 1 and 2.7 meters after observing human remains and stone bowls on the surface (Leakey and Leakey 1950: 2). It was revealed to be a dense burial ground with the remains of over 80 individuals.

Njoro River Cave was sampled for two reasons. First, it is the earliest dated occurrence of the Elmenteitan assemblage group to 3206-2787 BP (2900 uncal. bp) (Merrick and Mohanagan 1984). It is also the only Elmenteitan site where different raw materials were used to produce backed geometrics relative to the rest of the assemblage. There are 21 complete blades in the assemblage from Njoro River Cave that were included in the comparative analysis

Olopilukunya. Olopilukunya is an open air settlement site located at 1° 44'S 35° 42'E, at an altitude of 2020 meters above sea level, near the western edge of the Loita Hills. The site was exposed in a cattle track, with little to no visible material on the surface. The site itself is situated near a seasonal stream within open grassland (Robertshaw 1990: 268) and Charles Cable directed excavations of the site in 1985, which covered a total of 33.5 sq m. Excavators noted that archaeological materials were restricted to a 5-10 cm horizon, leading to the assertion that was at least a single phase, if not a single archaeological occupation (Robertshaw 1990: 269).

The artifact assemblages were analyzed jointly by Charles Cable and Peter Robertshaw. Ceramics and lithics are typical of the Elmenteitan, and the fauna was almost entirely domesticates (Robertshaw 1990: 272). The entire technological package has numerous similarities to those noted for the Elmenteitan of the Lemek valley, including the mean sizes for segmentary blades, and the frequencies of splintered pieces and microliths. Given the high rate of blade segmentation in this assemblage, only 10 blades were complete enough to include in the comparative analysis.

The Remnant Site. The Remnant Site is located at an elevation of over 2800 meters above sea level on the Mau Escarpment, and was excavated by C. M. Nelson, J. R. F. Bower, A. F. Waibel and S. Wandibba between 1975 and 1976. The site was identified as a single occupation with one uniform archaeological horizon 40 to 60 cm below surface, dating to 2315 ± 150 (Bower et al. 1977: 131). Two 2x2 m excavation units yielded a large quantity of lithics, ceramics, and bone,

and also revealed a set of postholes. The “Remnant ware” pottery style is now considered typical of the Elmenteitan (see Robertshaw 1990; Wandibba 1980), and the lithic assemblage from Remnant was used by C. Nelson (1980) to outline Elmenteitan technological strategies. As much as was identifiable, the fauna appears to reflect a typically Elmenteitan dominance of domesticates. A total of 29 blades were sampled from the large Remnant lithic assemblage.

Suswa Lava Tubes. This small Elmenteitan occurrence is located within 5 km south of the rich SPN Salasun site and Pickford’s Site (GuJi14) on the eastern slopes of Mt. Suswa. A small sample of surface materials including lithics and bones was collected by Glover et al. (1964) in the course of geological surveys of lava tubes. Lithics and ceramics from the collection were attributed to the Elmenteitan tradition by Glynn Isaac who analyzed the material (Glover et al. 1964). Ambrose (1984b) discusses this site as part of the Elmenteitan burial tradition, and the blades from the site morphologically match the long flat morphology typical for the Elmenteitan, along with varying degrees of dorsal-proximal faceting on the platforms. This lithic material from Suswa Lava Tubes is attributed to the Elmenteitan group, but it remains undated (Ambrose 1984b: 226; Merrick and Mohanagan 1984). Although it is problematic, a sample of eight blades is included because the site represents a rare Elmenteitan occurrence documented for Mt. Suswa.

Wadh Lang’o. Wadh Lang’o is a multi-component site with Kansyore, Elmenteitan, and Urewe materials similar to those at Gogo Falls. It was found during the course of mitigation surveys near the Sondu River along the eastern shore of Lake Victoria. Frederick Odede and Isaya Onjana supervised initial excavations between 1991 and 2001, and Ceri Ashley supervised another series of excavations in 2004 (Lane et al. 2007). Excavations covered, in total, 47 sq. m. of the site. A series of charcoal radiocarbon dates span the last 3300 years, with the Elmenteitan horizon dating to between 1532-1806 BP. Like Gogo Falls, deposits of Wadh Lang’o demonstrate a rapid

shift toward obsidian dominated lithic technologies within the PN layers relative to previous Kansyore deposits (Lane et al. 2007). At Wadh Lang'o, however, the faunal profile reflects a much higher reliance on domesticated animals by Elmenteitan groups.

Lane et al. (2007: 66) argue for stronger stratigraphic integrity at Wadh Lang'o, however they note that in some excavation units it was clear that Elmenteitan and Urewe materials were somewhat mixed. In order to limit the inclusion of post-Elmenteitan lithic material as much as possible, I predominantly sampled the more secure lower Elmenteitan strata for sampling. I did choose to include blades from other contexts where associated tools were morphologically Elmenteitan. From these contexts I was able to sample 18 blades.

5.9.3 Outgroup sample

I include one non-Elmenteitan sample in this analysis in order to understand whether or not the multi-variate analyses can be used to discriminate between assemblage groups based on the included variables. Narosura is an SPN site well within the temporal and geographic range of the SPN but with different technological patterns. Given the expectations that outgroup sample will in fact, group out, their inclusion is important for evaluating which principal components are the most meaningful for understanding broader Elmenteitan technological patterns. If Elmenteitan samples significantly cluster with the exclusion of the outgroup samples, it will confirm the quantitative validity of Elmenteitan technological signatures.

Narosura. Narosura is the type site for Narosura ceramics, and is considered one of the major type sites for the SPN outside of the Central Rift Valley. The site sits on the Narosura stream along the north-eastern side of the Loita Hills at an elevation of roughly 2000 meters above sea level. Knut Odner (1972) directed excavation of 22 sq. m. of Narosura, which may have been up

to 8400 sq. m. in total size. It is one of the few Pastoral Neolithic sites to yield evidence of multiple post holes and fire places. These all originate at between 70 and 90 cm below surface, making it likely they represent very few separate occupations (Odner 1972: 35). This is confirmed by the radiocarbon dates of 2925 – 2741 BP, with a single date from upper contexts that is somewhat later at 2539-2334 BP (Odner 1972). Material culture from the site is diagnostically SPN, and includes several groundstone and bone tools. A total of 10497 lithic pieces were recovered from the excavations. Obsidian composes 92.3% of the lithic assemblage, much of which apparently comes from sources near Lake Naivasha (Merrick and Brown 1984).

Table 5.4. Sites used in comparative analysis, with dates, distance from quarry, and sample size given.

Site	Code ¹	Date range (Cal. BP) ²	Distance from GsJj50 (km) ³	Reference	<i>n</i>
Enkapune Ya Sauli	EYS	2040 - 1480	20	Balasse and Ambrose 2005	53
Enkapune Ya Muto	EYM	3071 - 1932	25	Ambrose 1984b	41
Gamble's Cave	GAM	n/a	25	Leakey 1931, 1935	25
The Remnant Site	REM	2730 - 1935	27	Nelson 1980	29
Bromhead's Site ⁴	BRM	n/a	35	Leakey 1935	6
Lion Hill Cave	LHC	2044 - 1416	40	Bower et al. 1977	10
Njoro River Cave	NJR	3206 - 2787	50	Leakey and Leakey 1950	21
Suswa Lava Tube	SUS	n/a	60	Glover et al. 1964	8
Ngamuriak	NGA	2301 - 1528	100	Robertshaw 1990	51
Olopilukunya	OLI	2677 - 2094	130	Robertshaw 1990	10
Wadh Lang'o	WDL	1806 - 1543	170	Lane et al. 2007	18
Gogo Falls	GGF	1992 - 1610	210	Robertshaw 1991	17
<i>Outgroup</i>					
Narosura (SPN)	NAR	2925 - 2741	110	Odner 1972	47

¹ Abbreviation used in figures in Chapter 8.

² Age range is 2 σ , calibrated using OxCal 4.2 with SHCAL13 Curve (Hogg et al. 2013).

³ Approximate straight line measurement.

⁴ Mentioned in analysis sections, but not included in figures due to small samples sizes

Figure 5.9. Location of sampled P.N. sites in southwestern Kenya with major regions mentioned in text. See Figures F and G in Appendix III for site maps with modern landcover and mean annual rainfall.

Chapter 6

RESULTS I: ARCHAEOLOGICAL SURVEYS AND EXCAVATIONS AT THE ELMENTEITAN OBSIDIAN QUARRY (GsJj50).

This chapter reports on the results of archaeological surveys and excavations from the research season at the Elmenteitan Obsidian Quarry site in 2014. Basic inventories and typologies of the lithics, ceramics, and fauna are also presented with descriptive analysis. A particular focus of this chapter is understanding spatial patterns at the Elmenteitan Obsidian Quarry, which will become important for understanding how prehistoric peoples organized activities at the quarry were organized in prehistory. To this end, I integrated spatial mapping, survey, excavation, and material culture distribution data. Discussion of formation processes and taphonomy is included here, both of which are important for evaluating patterns in artifact distribution. Finally, this chapter reports on the radiocarbon dates obtained from the excavations.

6.1 Site mapping and survey

I estimate that fairly dense archaeological deposits occur discontinuously at the site over an area of roughly 300 m by 250 m, based on surface scatters and road-cut exposures. Within the site, large obsidian exposures are visible on the surface in several positions within the extent of the site. These vary from boulder-sized portions of the original obsidian flow, and semi-buried accumulations of more fragmented and weathered nodules (Figure 6.1). Quarrying here would have involved exposing and removing smaller nodules and spalling from larger exposures. I did not detect any evidence for quarry “pits” here like those documented in ethnographic obsidian quarries in Ethiopia (Gallagher 1977: 408-9). Mapping efforts revealed accumulations of large

obsidian cobbles and early stage split nodules, and large cortical flakes around several of the obsidian exposures. Smaller isolated scatters (typically less than 5 lithic artefacts per m²) occur over almost 400,000 m² around the site core. Both lithic density and size appear to decrease quickly with distance from the central quarry areas. Several large exposures of obsidian debris exist in areas outside the main quarry as we have identified it, but informants in the community universally claimed these were secondary deposits brought in from unknown locations during road construction.

Figure 6.1. Obsidian exposures within the quarry site. (A) Large obsidian pile- possibly spoil heap. (B) In-situ obsidian boulder. (C) Typical size for obsidian cobbles near surface.

The north-west boundary of the site is more sharply defined than the southern or western limits of the quarry, where the density of artefact patches fades gradually. There are additional scatters (>5 artifacts/ m²) beyond this extent visible in road cuts that diminish in size, density, and frequency moving away from the core of the quarry site. There are isolated obsidian flakes and small patches of debris (<5 artifacts/ m²) on the surface and in road-cut exposures extending over 300 m to the south. Surveys of the surrounding areas failed to locate any other Pastoral Neolithic

sites, quarries or otherwise, on the upper north-eastern slopes of Mt. Eburru. Occasionally these include ceramics, which in all cases appeared Elmenteitan. None of these were large enough to constitute an independent archaeological occurrence, and there is no current evidence for pastoralist residential sites on the upper slopes of Mt. Eburru. It is worth noting that sites located within the small valleys along the upper mountain slopes would be easily buried by colluvium and would not be detectable with walking surveys and unstructured erosional/road cut examinations.

Although surveys failed to detect any Pastoral Neolithic occupations on the upper slopes of Eburru near the quarry site, there was evidence for occupations along the mid-to-lower eastern slopes. Approximately 4.2 km east downslope of GsJj50 is a large (1.35 km x .72 km) flat grassland plateau that extends out from the mountain. This was a cultivated wheatfield owned by the Morgan Family for several decades. Transect surveys across the plateau located one artifact scatter eroding out of a cattle track along the steep southwestern corner of the plateau (Figure 6.2). I estimated an artifact density of roughly 5 artifacts per square meter across less than 10 total square meters. Isolated ceramic sherds and lithics were visible on the surface across a 50 m radius, but not further downslope to the south. All identifiable material appears diagnostically Elmenteitan. This likely constitutes a small, ephemeral, site, and not a significant habitation. In addition, there is a much denser MSA occurrence on the eastern tip of the plateau that is eroding out of a highly eroded cattle track. The coordinates for this site are N9930797, E 199376 (UTM Zone 37M).

Figure 6.2. Location of small Elmenteitan scatter on eastern slopes of Mt. Eburru. (A) Map of Mt. Eburru eastern slopes; (B) View eastward across the extent from the center of the Elmenteitan artifact scatter; (C) Example of artifacts collected from 4 sq.

Other sites are known from the middle- to-lower slopes of Mt. Eburru, and other than this small scatter we were not able to report any new Pastoral Neolithic habitation. The Masai Gorge site is the only other reported Elmenteitan site on Eburru, and is located at the eastern base of the mountain (Ambrose 1985, see map in Figure 2.6). Despite being within the territory of the Eburran hunter-gatherers, I did not locate any new sites of the Eburran hunter-gatherer traditions or a presense of Eburran type artifacts in the immediate vicinity of the quarry.

We were also able to conduct targeted surveys of several known caves and rock shelters within the Eburru Forest Reserve. These were all smaller than roughly 5 m², and none exhibited significant sediment accumulation. No archaeological material was visible within, or in the vicinity of, these features. This by no means rules out the possibility that people were living in the denser portions of the forest or exploiting forest resources in the past, and certainly the Ogiek have had a long historical presence in this area.

6.2 Excavations

6.2.1 Geological trench and depositional history

The geological test trench established the benchmark for understanding the depositional history and taphonomy at the site. Elmenteitan quarrying layers are near the surface, capping a sequence of andisols originating out of a pyroclastic ash overlaying consolidated pumice. Exposures of the pumice layer in road cuts suggest that it is at least 1m thick. Thinner pumice layers visible elsewhere on Eburru are not detectable in the stratigraphic sequence at GsJj50. There is clear upward leucinization through the column, suggesting predominately *in situ* pedogenesis. Soil development processes like humification are common in forested ecologies. Colluvial sediment very likely also contributed to the sequence. Boundaries within the B horizon are diffuse, without evidence for abrupt changes to the depositional process until Elmenteitan use of the site.

Soil development was greatly accelerated by anthropic inputs during Elmenteitan use of the site, contributing to the dark “midden” archaeological horizon that was deposited very rapidly. Evidence for erosion is sparse, even along the steep slopes downhill from the site and translocation of archaeological materials appears minimal. Thick vegetation has even prevented material turned up from recent road construction from eroding more than 10 meters downslope. Small lithic fragments occur in low frequencies up to 50 cm below the archaeological horizon, likely transported through root or rodent action. Insect activity was only evident in a few contexts above the archaeological horizon in Area 1. Rodent burrows were encountered in two excavation units, and both modern roots and evidence for decayed roots are common throughout the stratigraphic sequence across the site. The slightly leached B horizon between the archaeological horizon and modern surface (Figure 6.3: BAA) is largely sterile, further suggesting that agricultural activity

has not significantly disturbed the deposits in the excavated areas. Overall, root and rodent action appears to have the greatest effect on the distribution of archaeological materials.

The matrix is predominately silt throughout the column. There is a single undifferentiated archaeological horizon detected in the geological trench at a depth of 42 cm below surface. Sediment is overall much darker than overlying or underlying deposits, suggesting a high humic content, but is mottled with orange and darker black patches. A large black patch in Unit 3 was revealed to be a root cavity, and so it is likely that the color variation overall is related to biogenic activity, combined with reworking of the underlying orange B horizon. Above the archaeological horizon there is a higher degree of loam, and the archaeological horizon itself is slightly compacted clayish silt. Below this, the next 50-60 cm of sediment grades increasingly into a clayish silt. This is partially due to the higher percentages of volcanic ash that have been worked upward through the B horizon by bio-turbation visible in the stratigraphy. Isolated small obsidian artifacts occur up to 55cm below the archaeological horizon. Due to the small size of these few pieces it is possible they were translocated through the same root and/or rodent activity.

The above sequence is typical, but not entirely universal, for deposits below 65 cm below surface across the archaeological site. Differing degrees of slope resulted in less soil development along the western edge of the site, and there the sequence is compressed with the pumice layer being much closer to the surface. Additional flattening of the south-western portion of the site to construct an agricultural terrace in recent years has brought the plow-zone in that area closer to the archaeological horizon. As a result, the upper terrace is heavily disturbed in many places, evidenced by higher densities of obsidian debris intermixed in the plow-zone. Please see Appendix 1 for specific details on depths, Munsell color, grain size, inclusions, and descriptions for all levels in all excavated units.

GsJj50
UTM.37M
N9930211
E0194414

Figure 6.3. Litho-stratigraphic sequence at the Elmenteitan Obsidian Quarry, Area 1, Unit 1; (AAA) Modern zone of cultivation, Munsell: 10YR 2.2; (BAA) Subsoil Munsell 7.5YR 2.5/1; (ABA) Archaeological horizon/ paleosol, Munsell 10YR 2/1; (BBA-BBC) Holocene B- Horizon Munsell 10YR 3/2, 5YR 3.3, 7.5 YR 4/4; (BCA) Mottled combination of B horizon materials, Munsell 7.5 YR 4/4 (CAA) Volcanic ash, Munsell 7.5YR 2.5/3; (CAB) Volcanic ash with ejecta and pumice, Munsell 10YR 5/4.

6.2.2 *Excavation units in Area 1*

In Area 1 I excavated 8 sq. m., including the geological trench (Figure 6.3). I excavated three individual meter squares (Units 1, 2, 4) across a roughly 200m extent running parallel with the roadcut where it appeared there might be intact archaeological deposits. Only Unit 1 detected dense archaeological material. As a result, I expanded the unit into a 1x2 m trench running north-south. A second 1x2 m trench (Units 7, 8) was added 3m to the south of Unit 1, and oriented east west. Unit 10 was placed on the upper terrace in an area where very dense obsidian debris had been turned up by tilling several days earlier. Unit 11 was added to a small un-farmed patch used for grazing between Area 1 and Area 2 in the hopes of catching an interface zone. As it was clear from the geological trench, there were no archaeological horizons beneath the Elmenteitan layer excavations and I decided to terminate excavations at roughly 20 cm into the sterile B horizon.

Excavations in Area 1 revealed spatially discrete “midden” deposits of archaeological material that began between 40 and 50 cm below surface. In Unit 2 and Unit 11, sediment changes are barely visible or not detectable at all (Figure 6.4). In Units 1, 3, 7, and 8 midden deposits were between 20 and 25 cm thick and very distinct (Figure 6.5-6.7). Unit 10 was placed in an open area that was not under cultivation roughly between Area 1 and Area 2. The archaeological horizon in Unit 10 was only 15-20 cm thick and bisected by a large rodent burrow, with several large un-worked obsidian nodules at the base of the layer (Figure 6.8). The layers overlaying the archaeological horizon were heavily disturbed by roots, insects, and had evidence of extensive burning in the form of an ash lens and dense charcoal. Evidence of burning was well above the archaeological deposit and likely resulted from historic land-clearance.

Archaeological horizons in Area 1 feature very dense accumulations of cultural material and is noticeable as a darker stratum. Granules and pebbles of volcanic tuff and sometimes scoria

increase from “rare” in the loamy surface materials to “semi-abundant” approaching the archaeological horizon, and are typically “semi-abundant” or “abundant” within the it. Larger, angular fragments of very low quality obsidian are absent from all other strata, and are rare within archaeological contexts. When cobble-sized stones do occur, they tend to be clustered together.

Despite its location very near to a large exposure in the roadcut, Unit 4 yielded no evidence of the archaeological horizon, and very few lithic artifacts were found before the B horizon was encountered. Here, there was no discernable change in abundance or size of inclusions from the overlaying silts. This anthropic deposit is therefore not continuous across the site, but appears in discrete “patches”, roughly 10-15 m² in size. Between dense archaeological patches, the horizon was thin and diffuse, with very low artifact densities.

Archaeological material within these activity areas often occurred in discrete clusters along with ceramics, fauna, and unworked cobbles of coarse volcanics that were not found elsewhere outside of these clusters (Figure 6.9). This spatial pattern suggests rapid depositional conditions that sealed deposits with limited disturbance. These ranged from about 30 cm to 1 m in diameter. Later analysis showed no evidence for refits, suggesting these do not represent *in situ* knapping debris. Artefact clusters may represent caches, cleaning of the activity area, or “rummage” piles. The latter possibility is supported by higher occurrences of large, flat, and unmodified, blades at the bottom of clusters, with smaller debris at more variable orientations near the top.

6.2.3 Excavations in Area 2

Excavations in Area 2 revealed a more typical quarry deposit of dense and undifferentiated lithic debris (Figure 6.10, 6.11). Rich soils and rapid plant growth eventually worked to cover the archaeological deposit, however the presence of a dense stone layer prevented this area from being

farmed. Area 2 thus remains fairly densely forested and is probably similar to what the site would have looked like in the past. There would have been much greater potential for translocation of materials downslope when it was an uncovered heap of obsidian waste. Unlike the patches in Area 1, the archaeological layer in Area 2 is almost entirely composed of worked obsidian and angular obsidian fragments. There was no non-lithic material from the excavation in this area. The higher rates of angular debris and few tools in this area, and its proximity to surface exposures of obsidian suggests Area 2 was an initial quarrying and reduction area. There is a sharp spatial and behaviorally significant division between the quarrying area and the patches of mixed archaeological material in Area 1. Unfortunately, farmer construction of a small access path has destroyed what would have been the interface between these two areas.

6.3 Material Culture

Excavations at the Elmenteitan Obsidian Quarry produced a large sample of lithic materials, as well as ceramics and fauna. These are summarized in Table 6.1 by excavation unit.

Over 18,450 lithic artefacts with a total weight of 141.1 kg were collected during the course of this project, with an additional 11.35 kg of uncounted angular shatter ($<1 \text{ cm}^2$). This reflects an extremely dense archaeological deposit, even when compared to the substantial middens at sites like Prolonged Drift and Ngamuriak¹ (see Gifford et al. 1980; Robertshaw 1990). Not surprisingly, 99.95% of the chipped stone assemblage is obsidian. All of this is the bottle-glass green material characteristic of the upper Eburru source group, except for a single flake of grey obsidian that likely originated from one of the southern or western Naivasha sources. A breakdown of lithic

¹ For comparison, ~20 thousand lithic pieces were recovered from over 100 m² of excavation at Ngamuriak.

artefact class by core, tool, and debitage type is presented in Table 6.2. Blade debris comprises most of the assemblage, followed by debitage categories reflecting early stage nodule testing, core preparation and modification. Several complete blades are between 15 and 20 cm in length.

Figure 6.4. Unit 2 (N0199,E4431) south profile. Note that while a level of denser lithic debris was encountered, the archaeological horizon is not easily visible in the stratigraphy.

Figure 6.5. Unit 3 (N0211, E4415) south profile. Notice the archaeological horizon is more diffuse in this unit relative to nearby Units 7 and 8.

Figure 6.6. Unit 7 (N0206, E4415) south profile.

Figure 6.7. Unit 8 (N0207, E4415) north profile. Notice the recent agricultural furrow does not reach archaeological horizon.

Figure 6.8. Stratigraphic profile of Unit 10 (above), and close up of un-worked obsidian nodule with associated artifact cluster at the base of the archaeological horizon (below).

Figure 6.9. Discrete clusters of lithic debris within workshopping deposits of Area 1. Note variability in blade orientations, suggesting in-situ rather than translocated deposits. (A) Unit N4415-E0207, 48cm b.s., NW corner ; (B) Unit N0206-E4415, 40cm b.s., SW corner; (C) Unit N0207-E4415, 44cm b.s., SW corner; (D) Unit N0207-E4415, 59 cm b.s., SE corner; (E) N0211-E4414, 55cm b.s., NE corner; (F) Unit N0211-E4415, 40 cm b.s. Distribution of lithics across 1x1 at the interface with quarry deposits, NW corner left intact to display relative lack of cultural material in overlying sediments.

Figure 6.10. Excavation unit in central quarrying area (Area 2): (A) Typical view of quarry debris deposits during excavation; (B) Stratigraphic sequence showing density of material (SE corner).

Figure 6.11. Litho-stratigraphic sequence for Area 2, Unit 9 (main quarry deposit); (AAA) Surface soil/ loam; (BAA) Thin B-horizon; (ABB) upper archaeological horizon- appears to be mixed translocated material distinct from (ABA) extremely dense in-situ quarrying debris; (BBA) sterile sub-soil.

6.3.1 Obsidian quality

The range of obsidian quality at the quarry site was much greater than expected. A qualitative classification rubric was used to account for variation in internal crystallization, texture and opacity, the frequency of internal flaws, inclusions, and gas bubbles (see examples in Figure 6.12). Only 42.4% of knapped debris qualifies as “high-quality” or unflawed glass. This type of high quality obsidian dominates Elmenteitan habitation site assemblages far from the quarry site. Material with minor impurities such as banding, minor crystallization, or isolated flaws make up an additional 12.1%. In total, 45.5% of the obsidian flake debris had high ratios of internal impurities or major flaws. If angular fragments and core shatter were included in these calculations, the low-quality categories would account for roughly 65-70% of the total assemblage. A much higher proportion of the low-quality materials comes from Area 2. This supports the interpretation that Area 2 was used for extraction, testing, and early stage reduction, whereas nodule shaping and blade reduction occurred primarily in the activity “camps” in Area 1.

6.3.2 Cores

There are a total of 64 cores collected from excavations and surface surveys at GsJj50. Of these only 27 have elongate scars consistent with blade or bladelet removals, and 28 are informal flake cores. The remainder have bidirectional flaking, shattered platforms, and low edge angles consistent with bipolar reduction on an anvil. Elmenteitan assemblages often have high ratios of heavily worked pieces called *outils à caillès*, argued to be either formal tools (C. Nelson 1973: 208-226) or a type of bipolar core (Robertshaw 1988: 60-61). Damage patterns associated with *outils à caillès* can result from either use as wedge tools, or from bipolar reduction (de le Peña 2011).

Table 6.1. Summary of materials from excavation units. Northings and Eastings given in UTM, Grid 37-S, WGS-1984. This table does not include material from shovel test pits, surface collection, or sterile units 5 & 6 from Area 3.

	Excavation Unit								
	AREA 1								AREA 2
	U1	U2	U3	U4	U7	U8	U10	U11	U9
Northing (993-)	0211	0199	0211	0172	0207	0206	0203	0241	0241
Easting (19-)	4414	4431	4415	4475	4415	4415	4420	4368	4368
Lithics									
<i>Tools</i>	9	2	14	0	17	23	0	0	23
<i>Util. pieces</i>	11	2	33	0	41	85	1	0	28
<i>Cores</i>	1	3	2	0	13	19	1	2	22
<i>Blade¹</i>	31	26	115	20	271	321	24	14	469
All other debris	3360	815	1908	17	2953	3075	231	29	3369
Total lithics	3412	848	2072	37	3295	3523	257	45	3911
Ceramics	9	6	23	0	55	57	0	0	0
Fauna²	22	0	22	0	75	38	0	0	0

¹ This category includes only complete and proximal specimens.

² NISP for bone/tooth. Refitting fragments are counted as 1 only.

More recent experimental work has noted that bipolar pieces more often maintain morphological symmetry through their use-lives, whereas wedges do not (de le Peña 2015). Given the pieces in Elmenteitan assemblages are almost always symmetrical, it is possible that many served primarily as bipolar cores. I therefore follow Shott (1999) in referring to this artefact class as “splintered pieces”, and group them tentatively as a type of bipolar core. In doing so I stress that it is still very likely that they had multiple other uses. Very few splintered pieces were recovered from excavations at the quarry, and these have an average maximum dimension of 34.34 mm, making them quite large compared to the typical average length of 20 mm for splintered pieces at Elmenteitan habitation sites in the Lemek-Mara (Robertshaw 1990: 158).

Figure 6.12. Common forms of internal (non-cortical) flaws and inclusions evident in flaked obsidian at the Elmenteitan Obsidian Quarry: A, B, F) Course, granular texture; C) Fine granular and opaque texture; D) Vesicular planes; E) Opaque green-brown mottled coloration; G) Banded flaws; H) Pockets of major scoria-like flaws; I) Vesicular pockets. Horizontal black lines indicate 1 cm for adjacent piece(s).

Figure 6.13. Examples of typical blades from GsJj50, oriented with proximal ends up. Note varying degrees of dorsal-proximal faceting.

Table 6.2. Summary of lithic artifact types.

Artefact Category	<i>n</i>	% of cat.
Cores		
Blade	29	45.31
Flake	28	43.75
Bipolar	7	10.94
<i>Sub-total</i>	<i>64</i>	
Tools		
Shaped tools	94	54.65
Unshaped tools	78	45.35
<i>Sub-total</i>	<i>172</i>	
Debris		
Complete blades	401	2.20
Proximal blade segments	940	5.16
Complete flakes	223	1.22
Fragmentary debitage	16307	89.53
Core preparation/ modification	343	1.88
<i>Sub-total</i>	<i>18214</i>	
Total	18450	

6.3.3 Tool technology

Tools account for .005% of the total assemblage, a much smaller proportion than is typical for Elmenteitan habitation sites. Even so, tools provide some initial clues as to the range of activities that took place at the site, and the duration of quarrying episodes (after Gramly 1984). These are discussed below, roughly in order of tool size, and thus the location of the blanks within the blade reduction sequence. A summary of the tool assemblage is given in Table 6.3.

The most abundant shaped tool category in the Elmenteitan Obsidian Quarry assemblage is that of notched tools and denticulates. These are tools with one or more retouched notches made along lateral margins of a blade or blade segment (Figure 6.14: L-N). Early stage blades between 8 and 10 cm in length were predominantly selected for notch production. Notches themselves typically retain evidence of intensive uni-directional utilization, likely having been used as spoke-shave like tools to shape wooden implements and shafts. Strangulated blades and single notches

made on expended endscrapers or large blades are the common variants in Elmenteitan habitation assemblages (Robertshaw 1990: 124).

Only three burins were recovered, along with six burin spalls (see Figure 6.14: R, S). One burin is a typical burin *plân* on a blade segment, and the remaining two are dihedral burins with removals along opposed lateral edges of blades. Burins and burin spalls vary in size, but most are between 40 and 70 mm in length, suggesting removal from large blades. Burins are typically associated with graving or bone working (Andrefsky 2005: 161; Kay and Solecki 2000), but can also be opportunistic cores or hafted cutting tools (Barton et al. 1996).

Scrapers make up roughly 20% of the tool assemblage (Figure 6.14: I-K). Only three of these are convex endscrapers on blades or blade segments, which are the most common scraper types at Elmenteitan habitation sites (see Goldstein 2014). These have little wear along the working edge, but some do have minor lateral utilization. Two additional inverse endscrapers were manufactured on large elongate flakes derived from core preparation flakes. These deviate from typical PN endscrapers in that the working edge is created by removing flakes from the dorsal surface toward the ventral rather than *visa-versa*. Four specimens are “concave” endscrapers, which may alternatively be considered a type of notch tool. Side-scrapers also occur, and likely represent more opportunistic tool production and use.

Backed microlithic tools are made on small bladelets from late in the operational sequence (Figure 6.14: A-D). The only geometric forms present are crescents (n= 4) with lengths between 14 and 18 mm, which are well within the standard range for Elmenteitan crescents (Ambrose 2002). Crescents were frequently used as projectile points during the Pastoral Neolithic, but could also have served as cutting tools (see Goldstein and Shaffer 2016). The assemblage also contains a small number of backed or partially backed segments, oblique and lateral truncations, as well as

two larger curved backed flakes (Figure 6.14: G). C. Nelson (1980) and Ambrose (1985) noted similar bi-modal microlithic patterns of large backed blades and flakes with very small geometrics in early descriptions of the Elmenteitan industry. Otherwise, all of these microlithic variants tend to be common in regional LSA toolkits overall.

Lithic pieces that have clear evidence of utilization or retouch without an imposed shape are considered independently as “utilized pieces” (Figure 6.14: P, Q). There are 201 utilized pieces in the assemblage, including 123 utilized blades and blade segments, and 78 utilized flakes. Roughly one-third of the utilized pieces have minor edge damage consistent with casual use. Another 33% of these implements have semi-abrupt (<33 degrees) retouch.

Distributions of wear and utilization on these pieces appear un-patterned. Platforms are rarely retouched, however there is no part of the remaining flake margins that has significantly higher or lower rates of utilization. A general lack of patterning also describes the informal tools from the Elmenteitan site of Ngamuriak (Robertshaw 1990: 221). Flakes and blades were equally likely to be selected for opportunistic use, with both blank forms sharing an identical 8.7% rate of utilization. This supports the consolidation of informal tools into a single category, rather than breaking it up into sub-categories based on type and location of wear. The only discernable factor that seems to have influenced selection was blank size. Utilized pieces that are on complete or near-complete blanks have maximum linear dimensions that largely cluster between 5 and 17 cm. People using the site may have also been intentionally discriminating based on obsidian quality when selecting blanks for expedient tools. About 90% of the utilized pieces are on pure glass with few-to-no flaws or inclusions, and the remainder have only minor flaws. This stands out in an assemblage where low-quality pieces outnumber the pure glass blanks.

Table 6.3. Tool assemblage from the Elmenteitan Obsidian Quarry.

Tool Category	Count	Avg. L. (mm)	S.D.
Backed Pieces			
Geometrics			
<i>crescent</i>	4	16.47	0.99
Other Microliths			
<i>curved backed</i>	3	22.51	4.72
<i>lateral truncation</i>	2	35.17	1.22
<i>Oblique truncation</i>	8	27.30	4.89
Unshaped			
<i>backed flake</i>	6	30.52	3.37
<i>partially backed flaked</i>	3	22.51	4.74
<i>Sub-total</i>	26		
Scrapers			
Endscraper			
<i>convex</i>	3	48.91	1.72
<i>concave</i>	4	36.84	12.74
<i>inverse</i>	2	90.27	21.32
Convergent scraper	1	42.19	n/a
Nosed scraper	1	38.44	n/a
Side-scraper			
<i>Regular</i>	3	42.65	22.18
<i>Double</i>	2	43.56	1.35
<i>Denticulate</i>	1	65.56	n/a
<i>Inverse</i>	2	49.54	12.77
<i>Sub-total</i>	19		
Borers			
Awl	2	47.05	7.98
<i>percoir</i>	1	35.47	n/a
<i>Sub-Total</i>	3		
Burins			
Burin <i>plân</i> on segment	1	38.14	n/a
Dihedral burin	2	70.58	0.92
Burin spall	6	39.36	5.16
<i>Sub-total</i>	9		
Notch Tools			
Notches			
<i>Single notch</i>	11	57.18	23.78
<i>Inverse notch</i>	5	56.43	32.72
<i>Double notch</i>	4	50.69	26.68
<i>Strangulated blade</i>	3	58.16	27.74
Denticulates	7	57.94	8.64
<i>Sub-total</i>	30		
Combination Tools	7		
TOTAL	94

Figure 6.14. Tools and utilized pieces: A-E) microlithic crescents; F) curved backed bladelet; G) backed flake; H) oblique truncation; I) convex endscraper (fragment); J) steep endscraper; K) convergent sidescraper with bec; L) inverse notch; M) double, alternated notch, or “strangulated blade”; N) notch tool; O) awl; P) utilized blade; Q) utilized blade with invasive ventral retouch; R) burin spall; S) multiple burin *plân*. All pieces are obsidian.

6.3.4 *Ceramics*

Excavations yielded 167 pot sherds, all from Area 1. Although this sample is small for a Pastoral Neolithic habitation site, it is unexpectedly large for a lithic quarry. All sherds resemble typical Elmenteitan ceramics, sometimes termed “Remnant Ware” (Ambrose 1984a; Bower et al. 1977; Collett and Robertshaw 1983; Wandiba 1980). Consistent with the minimalist aesthetic of Elmenteitan pottery, only two sherds show any decoration. In both examples, this takes the form of a single row of discontinuous horizontal punctate impressions around the rim (Figure 6.15). Robertshaw (1990: 185) described this motif on Elmenteitan ceramics from the Lemek-Mara region. Undecorated sherds can be assigned to the Elmenteitan based on the presence of mica in the temper of all but two sherds, and the typically red-to-black coloration of the vessels (Robertshaw 1990; Ambrose 1984a).

Nine rim sherds allow limited discussion of vessel form. Rim sherd morphologies suggest steeply angled vessel walls, likely from straight-sided or hemispherical pots (Figure 6.15). All rim sherds appear to be from vessels with estimated original rim diameters of 40-42 cm. Collett and Robertshaw (1983) describe a ‘Type I’ variant of Elmenteitan pottery that match these size and shape specifications. Type I pots are the only large non-bowl forms known from Elmenteitan sites in the Loita-Mara (see Robertshaw 1990: 202-204). Although lugs and spouts are typical of Elmenteitan ceramics in the southwestern highlands, they are less commonly found on Type I vessels. This may partially explain the lack of lugs and spouts in the ceramic assemblage in the Elmenteitan Obsidian Quarry assemblage.

Typological indicators are important in contextualizing these materials. Consideration of additional technical and technological dimensions of vessel production and use are also needed in order to discuss the social processes involved in the formation of the ceramic assemblage (Ashley

and Grillo 2015). Many aspects of the ceramic technology at the Elmenteitan Obsidian Quarry exhibit considerable variability. Within the assemblage, sherd thickness is normally distributed around a mean of 9.57 mm (SD= 2.11 mm), however the full range of variation extends from 4 mm to 15 mm. Internal and external vessel colors range from black to bright reds and oranges. Finally, both the size of the ground mica used in the temper, and the density of mica within the temper vary greatly from sherd-to-sherd (Figure 6.16).

Only two sherds are close enough in temper composition and thickness to be possibly from the same vessel, and no sherds from the assemblage directly refit. Based on these attributes, it is probable that the collection reflects a larger, rather than smaller, minimum number of vessels. Langdon and Robertshaw (1985) have argued that most ceramic vessels at Elmenteitan habitation sites in the Lemek-Mara were locally made, given the distribution of clay and mica sources. In addition, Elmenteitan ceramic vessels are known to be generally thicker at Central Rift sites relative to settlements in the southwestern highland sites (Ambrose 1982).

6.3.5 Other material culture

Knapping equipment is represented in small quantities at the quarry site. Five small quartz fragments (totaling 14.99 g) are either cortical flakes from river-worn cobbles, or are rough angular shatter. This kind of debris does not reflect intentional knapping, but is produced when quartz cobble hammerstones are used in hard hammer percussion. One fragment of a rounded breccia nodule also resembles a hammerstone broken laterally during use. Finally, there is a single large fragment of a tabular granite abrader. Thirty-two fragments of ochre (totaling 148.42 g) were recovered from Area 1. Ochre is abundant in exposures immediately around the site, but is not present immediately up-slope. As a result, natural processes seem unlikely to be responsible for

their inclusion in archaeological deposits. Association of ochre with ceramics, fauna, and charcoal also points to intentional human transport to the activity areas. The color of the ochre fragments varies between dull yellows and dark reds.

Figure 6.15. Rim and body sherds from GsJ50, Area 1. Thickness of largest rim sherd given for reference.

Figure 6.16. Histograms of ceramic attributes at GsJ50; A) sherd thickness; B) density of mica inclusions in sherd matrix; C) size of mica inclusions in sherd matrix.

6.4 Fauna

Area 1 also yielded faunal remains in association with pottery and formal tools. In total, 77 fragments of bone, 13 complete or nearly complete teeth, and 81 unidentifiable tooth fragments (totaling 12.33 g) comprise the faunal assemblage. Bones and teeth were fairly evenly distributed across the lateral and horizontal contexts from which they were recovered. All of the bone is highly fragmented, with most pieces being between only 5 and 20 mm in maximum dimension, with no fragment exceeding 50 mm. Only one specimen is identifiable to element- a metapodial of a large sized bovid. Much of the unidentified sample of bone appears to be comprised of shaft fragments, and when discernable, these also appear to be derived from large-bodied mammals.

Over 93% of the bone from the site is burnt, and one specimen has apparent cut marks. Some burnt fragments have discrete darkened patches consistent with low temperature burning, and others show extensive calcined burning, which is more consistent with higher temperature fires (Shipman *et al.* 1984; Lyman 1994; Reitz and Wing 2008: 132). Many fragments show signs of burning across internal and external surfaces, and within interior break margins, indicative of exposure to fire after fragmentation. Most of the teeth were also fragmentary, often with the dentin completely absent. The dental assemblage includes three largely complete second or third molars, one complete incisor, five partially reconstructed molars, and five isolated pulp-chambers from molars. All identifiable teeth were from a size class 4 bovid. These may be from cattle (*Bos taurus*), although it is not possible to rule out Cape buffalo (*Syncerus caffer*) based on dental morphology alone. Wear on the molars was consistent with younger animals, although without complete tooth rows precise aging was difficult. An abundance of teeth and burnt fragments could reflect a taphonomic bias against uncarbonized bone given the wet conditions at the site. However, such

forces should not work against the preservation of small bovid teeth, which are conspicuously absent from the assemblage.

6.5 Radiocarbon dating

Three small pieces of charcoal likely derived from wood burned in fires from contexts in Area 1 were selected for AMS radiocarbon dating. Two of the charcoal samples were taken from near the top and bottom of the archaeological horizon in Unit 2, and these yielded uncalibrated dates of $2,170 \pm 20$ bp and $2,150 \pm 25$ bp respectively. A third sample was taken from the middle of the archaeological horizon in Unit 8, about 5m south of the previous two, and produced a date of $2,110 \pm 25$ bp. Slight inversion of these dates may suggest natural or cultural disturbance, however there is considerable overlap in error ranges such that they may simply reflect rapid deposition. These dates place activities in this locale firmly within the established chronology for the Elmenteitan.

Calibrated ranges for these dates support a hypothesis of rapid accumulation. When the dates are calibrated using OxCal v4.2.4 (SHCal13²) (Table 6.4) (Bronk Ramsey 2009; Hogg *et al.* 2013), the dense archaeological deposits in this area appear to have formed in under 200 years, and possibly over the course of only one or two generations. This is obviously only one snapshot of quarry activities within a much broader period of exploitation. Unfortunately, no datable materials were recovered from the other excavations within Area 1, or from the excavation unit in Area 2, which would help to understanding changing temporal and spatial patterns of quarry use.

² This is a southern hemisphere calibration curve. Although neither IntCal or SHCal will be 100% accurate for equatorial regions with rainfall from the fluctuating ITCZ, both calibration curves provide very similar date ranges for the Late Holocene.

A few charcoal samples were recovered from excavations of the cairn feature in Area 3. All of these were within the rock-pile feature. These were very large samples and appeared to be very recent. None of these samples have been sent for dating.

Table 6.4. Radiometric dates for GsJj50. Dating performed by Woods Hole Oceanographic Institution AMS Laboratory (NOSAMS). Calibrations employ OxCal (Bronk Ramsey 2010).

Lab ID	Provenience/ cm b.s.	Material Dated	$\Delta^{14}\text{C}$	^{14}C years		Calibrated range BP (2 σ CI)
OS-122182	Unit 1, 79	Charcoal	-242.15	2150 $\pm$ 25		2155 - 2008
OS-122183	Unit 3, 35	Charcoal	-241.11	2170 $\pm$ 20		2160 - 2041
OS-122184	Unit 8, 60	Charcoal	-237.25	2110	5	2106- 1996

6.6 Archaeobotanical remains

There were no apparent seeds or other archaeobotanical remains in the archaeological deposits apart from wood charcoal. There were also no pit or hearth features to target for taking sediment samples for flotation. I did, however, choose to take seven 2-liter sediment samples from the northwest corner of select 5cm spits within the densest parts of the archaeological horizon from Units 1, 3, 7, and 8. I was able to bucket-flot four of the seven 2-liter these samples while in the field³ as a preliminary assessment of their potential for yielding seeds or other remains. It was not possible to analyze either these samples or the remaining sediment samples, and all of these samples are currently curated at the National Museums of Kenya.

³ Following D. Q. Fuller - <https://www.youtube.com/watch?v=Nbkfe0B4zBg>

Chapter 7

RESULTS II: LITHIC TECHNOLOGY AT THE QUARRY

In this chapter I discuss the results of lithic analysis focused on core preparation and patterns of reduction in the lithic assemblage collected from the Elmenteitan Obsidian Quarry. Analyses include qualitative assessment of reduction phases, qualitative and quantitative attribute analyses, as well as measurement of metrics and morphologies. Following previous studies emphasizing the importance of identifying learning in lithic assemblages (see review in Chapter 3, section 6), I also present quantifications of error rates in the assemblage. In addition, I include assessments of spatial variation in these lithic signatures. These results are central to testing hypotheses regarding the social and economic organization of Elmenteitan quarry use, core preparation activities, and resource control or management (i.e. Robertshaw 1990). Results also establish the “start-point” for Elmenteitan lithic technological organization, making it possible to trace the Elmenteitan operational sequence fully from the Mt. Eburru source to sites across southern Kenya (see Chapter 8).

7.1 Core production and morphological variation

Few cores were recovered relative to what we might expect from a specialized quarry site. Moreover, the core assemblage does not reflect a single specialized blade reduction strategy. Of the total 59 complete cores and 5 core fragments recovered, over 40% are flake cores, and among these most are expedient, multi-platform, or bipolar. Even blade cores demonstrate high morphological diversity, with examples of parallel (n=16), opposed (n=5) and rotated (n=8) platform orientations.

7.1.1 Prepared cores

Single platform blade cores with parallel orientations make up just over half of the blade core assemblage. On average, only 60% of a core's total potential striking platform had been used for blade removals. This was almost always a continuous series, typically consisting of 5-10 visible removals. Cores thus exhibit a single reduction "face", and it appears that knappers oriented these along opportunistic angles on the nodule. Much of the core surface not being used for blade reduction retained weathered cortex. Core morphologies with a single reduction face describe 48% of the blade cores over 30 cm in height, and 77% of those with parallel flake orientations. Several incomplete fragments of cores also seem to reflect this morphology, suggesting it was a common strategy for initial core reduction. Only three single platform cores have pyramidal or cylindrical morphologies. One of these is a very early stage core that was abandoned when a substantial internal flaw was revealed, and the other two are <5 cm bladelet cores.

Opposed and transverse blade cores have generally the same morphologies as single platform parallel cores, only with additional removals along the same core face from the opposite end. On blade cores this often this appears to be related to attempts to remove large accumulations of step fractures or internal flaws, likely relating more to initial core preparation than to a maintained strategy of bi-directional flaking. Core rotation, where in the lateral blade scars along one core face are used as a platform for blades oriented at 90 degrees along another face, are more common and more systematic. Rather than exploiting one face of an obsidian nodule, rotated core morphologies allow for two separate faces to be in use simultaneously.

7.1.2 *Opportunistic cores*

A large percentage of the cores from the site were opportunistic or expedient. This includes 17 cores-on-flakes, and 10 multi-platform cores, and 7 bipolar cores (include splintered pieces). Platform count and orientation among the core-on-flake category are both highly variable with no clear patterns. These cores ranged from 77 mm to 14 mm in maximum dimension, and core size tracks well with both number of visible removals and number of platforms. These correlations indicate that more platforms are added as the core size is reduced through repeated removals. The *chaîne opératoire* for these implements thus begins with a large flake exploited along one margin, followed by the exploitation of adjacent or opposed margins as core size decreases, and ultimately resulting in radial reduction once the core is less than 30 mm long. Correlations between size and degree of exploitation (Figure 7.1) suggests that the preference was to intensively exploit a core-on-flake, essentially “curating” it by adding more platforms, rather than abandon it after a few removals in favor of a fresh blank. Intensive reduction of expedient cores is somewhat unusual in a quarry context where there is an abundant supply of obsidian to exploit.

A subset of the core-on-flake type are bladelet cores manufactured from large thick blades or flakes. In these cases, the blank was turned on its side and bladelets were removed by striking laterally such that the width margin of the blank became the length margin of bladelet products. This transverse bladelet removal strategy bears some resemblance to the Yobetsu bladelet technique, with flake blanks substituted for bifacial blanks (see Kobayashi 1970).

Figure 7.1. Relationship between flake scar count and core size. $R^2 = -.42$

The narrow flaking surface allows for narrow, burin-line bladelet blanks to be removed very easily with little risk of error and little need for platform maintenance. Only one piece has evidence of attempts to refresh the platform, and in this instance that blow resulted in a substantial plunging termination that over-shot and split the core. These cores are small, and the primary bladelet reduction face was typically under 50 mm long. This technique reflects a clear intention to produce bladelets, but without the imposition of a formalized core design. They are not intensively reduced, and in at least two cases they were abandoned when an attempt to modify the platform broke the piece.

Analysis of multi-platform expedient cores, made on nodules or large obsidian fragments, did not demonstrate any correlations between metrics or attributes. Multi-platform cores range from maximum dimensions of 85 mm – 30 mm. They have a similar size range and distribution as the single faced parallel core morphology, making them one of the largest core size classes. It is therefore unlikely that they result from increased reduction of other core types. Expedient reduction of flakes from multiple core angles is a strategy that is maintained from the beginning

of exploitation through core abandonment. Multi-platform cores appear to exist within a separate and independent reduction sequence from other core classes.

The final class of expedient cores are bipolar pieces. Bipolar cores vary widely in overall volume, however all seven specimens have flaking surfaces that are less than 50mm long. Two of the bipolar cores are derived from angular obsidian fragments with an opportunistic edge exploited through bipolar reduction against an anvil. Five of the bipolar cores are either *outils à caillès* or *bâtonnetes* on blade segments.

Figure 7.2. Estimated core volume distributions by core class. Radial and rotated cores were not included due to small sample sizes. Outliers over 2 standard deviations are marked with (*).

7.1.3 Core preparation and modification debris

A total of 404 pieces were identified as being related to the modification of obsidian cores. Over 82% of this category is what is labeled “preparation debris”, or flakes that were removed in the process of reducing an unprocessed obsidian nodule into a blade core. These are classified as “early”, “middle”, or “late” depending on their position within the relative chaîne opératoire for core preparation (Figure 7.3, 7.4, 7.5). See Tables 7.1 and 7.2 for a quantities and attribute

summaries for core preparation debris from this assemblage. Early stage preparation flakes are predominantly large cortical removals or are removals of angular protrusions or other undesirable morphological features from a nodule. These flakes are thick, with large platforms and pronounced bulbs indicative of hard hammer reduction (Dibble and Pelcin 1994).

Middle stage preparation flakes reflect subsequent modification aimed at shaping or refining a core. If cortical removals left steeply angled edges, they were trimmed and removed at this stage to produce a rounder and more regular face for blade removals. The second most common category of middle-stage preparation flakes is the intentional removal of large internal flaws, remnant step or hinge fractures, or smaller patches of cortex (Figure 7.4). Middle-stage reduction also involved the initial set-up of striking platforms, as evident in the frequency of half-prepared platforms that were reset with large core-tablet like removals. In at least three cases the tentative platform was aborted due to hinge or step fracturing, however in many examples it is difficult to determine if the removal of a platform was intentional or an accidental over-removal. There does not appear to be any systematic strategy for accomplishing the varied objectives of this stage of core preparation, as reflected in the variability in flake scar orientations.

Late stage preparation debris is characterized by the apparent efforts to impose the actual blade release surface. This often includes the removal of the opportunistic platforms from earlier phases of preparation and finer adjustments and preparation to blade release platforms. At this stage platforms begin to be prepared more seriously, and characteristic heavy grinding and dorsal proximal faceting become more common. Platform removals from this stage can only be distinguished from those removed during later blade reduction because there is little-to-no evidence of serial blade removals from the prepared platform.

Figure 7.3. Miscellaneous examples of middle stage core shaping/ platform removals. Note radial scar patterns and removal of weathered surfaces.

There is continued effort through this stage of preparation to shape and smooth the core “face” through the removal of elevated edges. Small patches of flaws, inclusions, or granular features that were missed previously appear to be specifically removed here as well (see Figure 7.4 D-G). Debris reflecting the preparation of cresting blades is also included here. This is the alternating removal of flakes across two sides of an edge to create an artificial aeris running in parallel to the planned direction of blade removals, effectively guiding the initial blade. The succeeding cresting blade is a flake that removes this aeris, establishing the sequence for formal blade removal. Removals of blades after this point are not included as preparation debris.

Figure 7.4. Core preparation debris. (A) Early stage cortical removal; (B-C) middle stage core shaping; (D-G) middle-to-late stage removal of high ridges, material flaws, cresting blades. Black bars = 1 cm.

The remaining core modification pieces are either removals of platforms (n=60), core tablet removals (n=3), or heavy blows to remove stacked step fractures or deep hinge terminations (n=9). Unlike preparation flakes, these modifications appear to have taken place within the operational sequence of blade removal, and so reflect core maintenance during artifact use-life. Most platform removals either *flanc* removals (oriented at 90 degrees to the platform) that are initiated and run parallel to the blade axis, or are removals perpendicular to the prepared striking platform, removing part of both the striking platform and the core face (*lames à crête*) (see Brézellion 1968: 97). Some platform removals appear to be accidental, while others appear to be intentional removals of material flaws or large step or hinge fractures on the core face.

Parallel, or *flanc*, removals that serve to readjust striking platform angles tend to be smaller and appear derived from cylindrical or pyramidal bladelet cores. Perpendicular platform removals are larger, and the sometimes large portion of the core face they remove reflect relatively flat and straight flaking surfaces.

Particularly in the case of perpendicular platform removals, it is common that a flat surface was heavily prepared as a platform, but then removed without any attempt actually to remove blades from that platform. This also characterizes platform removals at several Elmenteitan sites across southern Kenya, including Enkapune Ya Sauli, Ngamuriak, and Olopilukunya. Such a platform modification could derive from many types of blade cores. Given the overall morphologies and flake scar patterns in this site, it is likely these derived from rotated cores like those well represented in the core assemblage.

Figure 7.5. From left to right, Early stage removal, middle stage removal, late stage removal/initial blade removal.

7.1.4 Intra-site spatial variation

There are no statistically significant differences in the core assemblages between Area 1 and Area 2. This is true for ratio of formal to expedient cores ($\chi^2 = .964$, $p = .32$), length of release surface of cores (Mann-Whitney $U = 417$, $z = -.96$, $p = .34$), and core volume (Mann-Whitney $U = 383$, $z = -1.19$, $p = .23$). The size distribution is slightly skewed toward smaller cores in Area 2, but again these differences are not significant. As noted above, there is a difference in obsidian quality between the two areas that is reflected in the core assemblage. Only 20% of platform removals come from the excavation unit in Area 2, but this represents only one 1x1 m trench. When controlling for excavation area, the density of platform removals is about equal across the rich archaeological units in Area 1 and Unit 9 in Area 2. Using these same standards, core preparation debris and cortical removals are over represented in Area 2, with nearly 50% of all such debris coming from the single Unit 9 excavation.

7.2 Overview of the debitage assemblage

The debitage recovered from the Elmenteitan Obsidian Quarry consists of 1341 blades that are either complete ($n = 401$) or are proximal fragments retaining the striking platform ($n = 940$). There are 223 complete flakes that do not have an elongate blade morphology, and an additional 16307 pieces of debitage that are proximal (non-blade), medial, distal, indeterminate, or are angular shatter. In total, the collection from the site includes 18,450 lithic artefacts with a total weight of 141.1 kg. There is an additional 11.35 kg of $< 2\text{mm}^2$ flake shatter that was not counted.

It is not possible to ascertain to what degree the medial and distal fragments are related to the platform bearing proximal fragments, and so it is best to rely on only proximal and complete debris to estimate the MNI for blades and flakes. Using this method, the ratio of blades to flakes

in the assemblage is roughly 3.5:1, meaning there are over three times as many blades as flakes in the assemblage. Unlike the core assemblage, the debitage suggests that the systematic reduction of blades was a major activity at the quarry site. Indeed, the production of blade blanks is known to be the focus of Elmenteitan technological organization regionally (Ambrose 2001; C. Nelson 1980). The bulk of the analysis here will therefore be focused on blade production, with a few cursory comments on the flake assemblages.

Table 7.1. Frequency of flake debris related to core preparation and modification.

Type		n
Hinge/step removal		9
Platform removal		
	Parallel	16
	Perpendicular	28
	Opposed	4
	Oblique	1
	Multi-directional	3
	Indeterminate	7
	Tablette	4
<i>sub-total</i>		60
Preparation		
	Early stage	61
	Mid-stage	170
	Late stage	96
	Cresting blade	5
<i>sub-total</i>		332
Total		404

Table 7.2. Flake scar orientations on different states of core preparation flakes.

Flake scar orientation	Preparation stage			
	EARLY	MIDDLE	LATE	<i>Total</i>
Cortical	24	10	3	37
Uni-directional	13	46	37	96
Opposed/bidirectional	4	28	21	53
Alternated	5	45	20	70
Radial	2	41	13	56
Ind.	5	7	1	13
<i>Total</i>	53	177	95	325

7.3 Blade technology

7.3.1 Blade metrics

Distributions for blade length, width, and thickness, all display a skew toward large sizes. This is most pronounced for lengths. The mean blade length is only 58.50 mm (59.89 mm if step and hinge terminations are eliminated from the sample), with a 95% CI ranging from 18-107 mm. There are some twenty blades that outliers by at least one standard deviation, running up to a maximum of 190 mm. These are among the largest blades documented for the Holocene in sub-Saharan Africa, but are not surprising coming from an obsidian source and workshop site. Width and thickness appear less variable, and these feature fewer extreme outliers (Figure 7.6).

Figure 7.6. Metrics for all blades.

Intra-site variation in blade length is minor (Figure 7.7), and the overall distribution for the whole site is presented in Figure 7.8. Blades from both of the denser archaeological “patches” in Area 1 have similar distributions in lengths, although the upper-terrace of Area 1 (Units 10, 11) have a higher overall mean blade length. One possibility is that this is simply artifact of sample size, as only 27 complete blades were recovered from the upper terrace excavations. Alternatively, this may reflect an actual pattern as the upper terrace units did yield several medial blade fragments in excess of 15 cm, which were not included here. Blades from the thicker quarrying and processing debris layer in Area 2 (Unit 9) have a similar mean length when compared to Area 1, but with a distribution that is skewed slightly toward smaller blades. The difference between Areas 1 and 2 is technically statistically significant (Mann-Whitney U: $z=-2.37$, $p=.018$). This diminishes as outliers are removed, and given the similarity in means blade length between areas, these differences should be viewed skeptically. There are no significant differences in either blade width or thickness between Units or Areas within the site.

Figure 7.7. Blade length by context (with jitterplot). All N=371, Area 1 lower (Units 1, 3, 7, 8) n=154; Area 1 upper (Units 10, 11) n=27; Area 2 (Unit 9) n=192. Outliers over 1 s.d. marked with (o), outliers over 2 s.d. marked with (*).

Comparison of these measurements in biplots (Figure 7.11) further demonstrates the high degree of morphological variability in the blade assemblage. All dimensions do scale with each other such that longer blades tend to be thicker and wider, however all correlations are relatively weak. Thickness-to-length is the weakest correlation. This is interesting in light of previous work on assemblages from the Loita-Mara region, which found blade thickness was a strong predictor of length at both Elmenteitan and SPN sites (Goldstein 2014). Taken together, the variation in these distributions suggests that there is little consistency in blade morphologies, and any two blades of equal length, width, or thickness, could vary considerable in the other two dimensions. Correlations between any two variables are neither stronger nor weaker across excavation areas.

Figure 7.8. Histogram for complete blade lengths at GsJj50.

7.3.2 Striking platforms

In total, 1,040 of the blades in this assemblage had measurable platforms. The most common form of blade platform preparation was abrasion or grinding with varying degrees of dorsal-proximal faceting (54.6%) (Figure 7.9). Platforms prepared in this manner were consistently small, with a mean total platform area close to 30 mm². Plain or “flat” platforms with little, or no, edge preparation were also very common, totaling 40.7% of the assemblage. Unmodified cortical platforms indicative of early core reduction were rare, accounting for only 2.2%. Platforms exhibiting large facets or micro-faceting along the platform also occur, but in low frequencies. All of these platform types are wider and thicker than the heavily ground types, with

means between 73 and 145 mm². Table 7.3 provides summary data for platform types and platform sizes.

Complete blades with ground platforms and dorsal-proximal faceting are on average the longest ($\bar{x}$ = 6.72 cm), and are the only type to exceed 17 cm. Blades with faceted platforms have a similar mean length, likely due to being early removals from large cores. Platform preparation resulted in overall longer blades in comparison to those with unprepared or plain platforms, and that relationship is found to be statistically significant (Mann-Whitney U : 6079.5, z = -4.08, p < .05).

Figure 7.9. Examples of dorsal-proximal faceting (DPF) on proximal blade fragments- note variation in the depth and intensity of DPF.

I noted three variants within the “dorsal-proximal faceting” class of preparation. These are (1) dorsal proximal faceting that was restricted to the edge of the striking platform with a large portion of the platform face being plain or lightly ground; (2) standard dorsal-proximal faceting

with very small striking platforms (*sensu* Ambrose 2001); and (3) platforms that are heavily ground but with minimal grind-faceting along the dorsal-proximal face. On average the large DPF platforms are over 30 mm² larger than the standard DPF platforms (Figure 7.10). The heavily ground platforms are only slightly (~6 mm²) larger than normal DPF types. Differences in distribution medians among, and between, all three categories have statistical significance (Kruskal-Wallis $\chi^2 = 84.66$, $p < .05$).

Although only 16% of the “DPF” platforms are classified as having preparation restricted to the dorsal platform edge, it does represent a technologically significant deviation. Despite preparing the edge, these were removed either with imprecise hard-hammer techniques or had the indirect punch placed an atypical distance back from the platform edge.

Figure 7.10. Average platform area for different forms of DPF preparation. (n=92, n=252, n=228).

Figure 7.11. Biplots of primary blade measurements for normally terminating blades (n=206). (A) Length/ thickness, $r^2=.39$ (B), Thickness/ width, $r^2=.49$ (C) Length/width, $r^2=.41$.

As is the case for basic metrics, proportions of platform types is consistent between the upper and lower terrace excavation units (Figure 7.12). Compared to Area 2, 23% more of the blades in Area 1 have platforms prepared through dorsal-proximal faceting. Area 2 is dominated by blades with no preparation platform (plain platforms). The higher proportion of typically larger plain platforms in Area 2 naturally means that Area 2 has a high average platform size. Distributions of platform sizes within any one class of platform preparation are more consistent across excavation areas. For example, platforms with DPF have a mean area of 40.95mm² in Area 1 and 33.60 mm² in Area 2, and these differences are not statistically significant (Mann-Whitney U: 22427, z= -1.845, p=.198). The true means may be even closer together, as Area 1 has a higher proportion of DPF platforms that were too small to measure and were not included in these calculations. Platform preparation is applied at different rates in different parts of the site, but the preparation strategies appear fairly consistent when they are applied.

Figure 7.12. Proportion of platform type by excavation area. (Area 1a= lower terrace excavations, Area 1b= upper terrace excavations).

Table 7.3. Summary of blade platform types and metrics. This table only includes specimens with fully intact and undamaged platforms and no evidence of being modified after blade removal. From Goldstein and Munyiri 2017.

	Platform Type	n	Avg. Platform Width (mm)	Plat. Width SD (mm)	Avg. Platform Thickness (mm)	Plat. Thickness SD (mm)	Avg. Platform Area (mm ²)
<u>Blades</u>	Abraded (w/ DPF)	568	8.18	4.20	3.04	1.51	29.31
	Plain	407	15.73	7.34	6.77	3.47	127.24
	Plain (<i>Chapeau de gendarme</i>)	16	18.35	6.70	3.78	1.59	76.47
	Cortical	23	16.40	7.10	7.54	4.77	144.86
	Faceted	17	28.47	16.43	11.02	7.37	92.98
	Micro-faceted	9	14.93	4.44	6.69	3.28	73.69
	<i>All measured platforms</i>	<i>1040</i>	<i>11.79</i>	<i>7.47</i>	<i>4.80</i>	<i>3.42</i>	<i>78.38</i>
<u>Flakes</u>	Abraded (w/ DPF)	30	11.80	4.89	4.00	1.92	50.55
	Plain	243	19.65	8.83	7.39	3.53	168.31
	Plain (<i>Chapeau de gendarme</i>)	17	27.48	7.85	5.15	2.19	150.80
	Cortical	9	16.38	7.18	6.88	3.18	127.40
	Faceted	17	28.01	12.43	9.84	4.04	301.13
	Micro-faceted	2	15.01	8.52	5.39	.03	80.76
	<i>All measured platforms</i>	<i>318</i>	<i>19.71</i>	<i>9.36</i>	<i>7.04</i>	<i>3.57</i>	<i>161.62</i>
<u>Core Preparation</u>	Abraded (w/ DPF)	44	12.66	7.66	4.43	2.92	74.58
	Plain	243	26.82	14.90	11.66	6.48	387.38
	Plain (<i>Chapeau de gendarme</i>)	2	37.68	9.03	9.99	1.56	369.13
	Cortical	26	22.22	8.99	9.74	4.62	244.24
	Faceted	22	32.74	13.95	13.42	5.72	486.22
	Micro-faceted	4	17.84	6.90	10.43	5.01	208.82
	<i>All measured platforms</i>	<i>341</i>	<i>24.93</i>	<i>14.58</i>	<i>10.67</i>	<i>6.43</i>	<i>340.41</i>

Figure 7.13. Bivariate plot of ratios of platform width to blade width and platform thickness to blade thickness for blades from GsJ50 (following Ambrose 2002). Blue line represents the linear regression line for these data (Linear $r^2=.65$, $p<.05$). Larger blades tend to have less stable platform size-to-blade size relationships.

Platform preparation may be related to blade length, however platform size is a generally poor predictor of blade length for those produced from the quarry site. Previous analysis (Goldstein 2014) also found this to be the case for blades from Ngamuriak and Narosura. Platform width and platform thickness do seem to be fairly strong predictors of blade width and blade thickness (Figure 7.13). This relationship was first identified Ambrose (2002), who discussed it in terms of different blade production techniques as strategies to manage high quality lithic raw materials. Manipulating platform width and/or thickness, through different degrees of platform preparation discussed above, would have given knappers the ability to create blades of a predictable width, thickness, or more generally cross-sectional area (width x thickness).

7.3.3 *Flake scar orientations and counts*

Parallel flake scar orientations remain the most common scar pattern throughout all phases of blade reduction. These reflect either single platform cores, or rotated cores where the blade removal faces do not intersect. Bi-directional flake scars, indicative of opposed platform cores, are relatively uncommon and make up only 9% of all complete blades. Radial, alternated, and oblique orientations occur in similar, or lower, frequencies through the reduction sequence (see Table 7.4). Differences in the ratios of flake scar orientations by blade length quartile are not statistically significant ($\chi^2 = 11.712$, $df = 12$, Monte Carlo $p = .47$). Orientation results are overall consistent with the core data in showing a prevalence of single platform or rotated platform core designs.

Proportions of flake scar orientations are consistent across excavation areas as well as throughout the reduction sequence (Table 7.5). Considering only whole blades, Area 2 appears to have a slightly higher ratio of parallel orientations, whereas A yields more alternating and oblique scar patterns. This difference is approaching significance ($\chi^2 = 9.0515$, $df = 4$, Monte Carlo $p = .057$). Increasing the sample size by adding flake scar orientation data from proximal fragments can increase may help to elucidate the pattern. Only proximal fragments that preserved a significant amount of the total blade were included. Even so, there is a greater chance that opposed or alternated flake scars were not preserved, and so parallel orientations could be over-represented. Ideally, any bias would affect both excavation area samples equally. When proximal samples are included, flake scar orientations appear in very similar proportions between Area 1 and Area 2 samples ($\chi^2 = 5.654$, $df = 4$, Monte Carlo $p = .22$).

Counts of dorsal flake scars visible on complete blades, irrespective of orientation, do show variation through the reduction sequence. Larger size class blades tend to have more dorsal scars, and half all blades over 70 mm in length have four or more visible flake scars. This ratio shifts

toward fewer dorsal flake scars as blades become smaller. Bladelets (blades under 45mm) tend to have three or fewer flake scars. These differences are statistically significant ($\chi^2 = 41.54$, $df = 12$, Monte Carlo $p < .05$). In part, this is a product of longer blades being typically wider, and wider blades being more likely to intersect with a greater number of previous flake scars. Only a portion of the variability in flake scar count is explained by width, however there is a positive correlation between these variables (Spearman $\rho = .28$, $p < .05$). Flake scar counts are equally distributed between excavation areas (Figure 7.14).

Table 7.4. Flake scar directionality data for complete blades.

Scar pattern	Blade length							
	<45 mm		45-55 mm		55-70 mm		>70 mm	
Parallel	105	77.8%	60	75.9%	55	69.6%	57	73.1%
Bi-directional	14	10.4%	6	7.6%	7	8.9%	8	10.3%
Alternated	10	7.4%	6	7.6%	7	8.9%	10	12.8%
Radial	3	2.2%	1	1.3%	2	2.5%	0	0.0%
Oblique	3	2.2%	6	7.6%	8	10.1%	3	3.8%
<i>Total</i>	<i>135</i>		<i>79</i>		<i>79</i>		<i>78</i>	

Table 7.5. Flake scar count data for complete blades.

Scar count	Blade length							
	<45 mm		45-55 mm		55-70 mm		>70 mm	
1	8	5.9%	5	6.3%	8	10.1%	1	1.3%
2	48	35.6%	24	30.4%	21	26.6%	9	11.5%
3	54	40.0%	30	38.0%	26	32.9%	28	35.9%
4	22	16.3%	15	19.0%	13	16.5%	26	33.3%
5+	3	2.2%	5	6.3%	11	13.9%	14	17.9%
<i>Total</i>	<i>135</i>		<i>79</i>		<i>79</i>		<i>78</i>

Figure 7.14. Flake scar orientations for excavations areas A and B with only complete blade data (left), and both complete and proximal blade data (right).

7.3.4 Symmetry and curvature

Blades produced at the Elmenteitan quarry site are overwhelmingly straight, and asymmetries tend to be minor (Table 7.6). Only 25 complete blades out of the sampled 371 had plan view asymmetries that exceeded 30 degrees, and none had asymmetries that exceeded 60 degrees. A greater proportion of asymmetries is found amongst the blades that exceed 70 mm in length. This should not be surprising, as larger and less prepared cores have larger faces and more opportunities for blades to skew laterally. Once parallel flake aerises are established, it is more likely that succeeding blade removals will follow them and thus also be parallel, and that appears to occur more consistently by the time a core reaches 70mm in height. Even though the higher rate of asymmetries in the larger blade size class appears substantial, the differences are not statistically significant at a 95% confidence interval ($\chi^2 = 15.609$, $df = 12$, Monte Carlo $p = .201$).

Table 7.6. Symmetry of blades relative to dorsal view.

		Blade length							
Symmetry		<45 mm		45-55 mm		55-70 mm		>70 mm	
Straight		109	80.74%	56	70.89%	66	83.54%	50	64.10%
Right	<30°	11	8.15%	9	11.39%	4	5.06%	13	16.67%
	>30°	2	1.48%	2	2.53%	2	2.53%	2	2.56%
Left	<30°	7	5.19%	6	7.59%	5	6.33%	10	12.82%
	>30°	6	4.44%	6	7.59%	2	2.53%	3	3.85%
Total		135		79		79		78	

There are significant differences in the proportion of asymmetries between (but not within) excavation areas. Comparing a pooled sample of blades from Area 1 against those from Area 2, it is clear that Area 1 features a much higher proportion of asymmetrical blades. Straight blades account for 83% of the assemblage from Area 2, and only 66.2% of the assemblage from Area 1.

Blades exhibit overall very low curvatures, with 56.7% of all complete blades having curvature profiles of 180 degrees (i.e. flat). Another 12.3% of curvature profiles fall between 170-180 degrees, being effectively flat. Only 31% of all blades have curvatures values high enough that they may reflect real significant differences in the shape of the cores removal face. Figure 7.14 below demonstrates that average curvatures are highest among the largest blade size classes, and decrease significantly through the reduction sequence.

This pattern of decreasing, rather than increasing, curvature through the reduction sequence reflects a deliberate effort toward keeping blades flat by manipulating core shape. Such a pattern supports the observations made by C. Nelson (1980) and Ambrose (2001) for the presence of consistently flatter blades in Elmenteitan lithic assemblage relative to SPN or Eburran assemblages, and indicates that this is imposed at the quarry and maintained at Elmenteitan sites. Based on data from the Elmenteitan Obsidian Quarry, blades reach a consistent average of at least 170 degrees (nearly flat) by the time a core is < 80mm in height.

Figure 7.15. Average blade curvature by length size class. Error bars reflect one sigma standard error. Note that lower curvature values reflect higher curvatures.

There are no differences in the distribution of curvatures in Area 1 excavations. Area A does have a statistically higher median blade curvature distribution (Mann-Whitney U: 12557, $z = -2.304$, $p = .021$) in comparison to Area 2. This difference is entirely due to the higher proportion of larger blades in Area A, and does not reflect behavioral or strategic differences in core morphologies within the site.

7.3.5 Cortex

Cortical coverage on blades is generally low, with an average dorsal cortex of only 2.7%. Contrary to expectations that dorsal cortex should decrease through the reduction sequence, the

opposite correlation appears to be true. This pattern is created by two “spikes” of high cortex rates that occur when blade length (i.e. core height) is around 100 mm and between 60-40 mm (Figure 7.16, 7.17). These may reflect stages of core reduction where it becomes necessary to re-orient the core and operationalize new or alternative platforms. Utilizing parts of the core that were previously un-modified results in blade removals with high dorsal cortex. Average dorsal cortical coverage is somewhat higher in Area 2, however the difference is not significant (Mann-Whitney U: 13978, $z = -.931$, Monte Carlo $p = .364$).

Figure 7.16. Dorsal cortex on blades by blade length.

Figure 7.17. Average dorsal cortex by overall reduction state.

7.3.6 Terminations

Blade terminations relate to core shape and reduction style, as well as skill and production technique. Terminations were classified for 345 complete blades, supplemented by an additional stratified-random sample of 197 distal blade fragments (Table 7.7). Proportions of termination types is consistent between the complete and distal samples.

Ratios of termination types are virtually identical for Areas 1 and 2, with normal terminations accounting for just over 50% of all terminations. Plunging terminations, wherein a blade removes either the opposed platform or distal end of the core make up about 18% of all terminations. By removing a portion of the core base, each plunging termination makes the core shorter, reducing the maximum potential blade length of the succeeding removals. For this reason,

it is sometimes viewed as an undesirable error. More obvious mistakes come in the form of hinge of step terminations, which describe 27% of all blade terminations. In sum, 45% of all blades produced at the Elmenteitan Obsidian Quarry demonstrate a form of production error.

Languette fractures are also typically seen as a common error of blade production (Tixier 1999), but can be difficult to distinguish from intentionally segmented blades or from breakage due to post-depositional trampling. Languette breaks were counted, but due to the possibility of biased identification were not included in the counts given above. If included, the 120 identified instances of languette snaps would account for 18% of all errors that occurred at the moment of blade removal, bringing the rate of such errors to 54% of the total. Other possible forms of termination breaks like siset (split flake) breaks are even more difficult to distinguish from taphonomic breaks or snaps, and I did not attempt to distinguish between these in the debitage analysis. As a result, this rate of potential termination errors is probably a fairly conservative estimate. Languette breaks also appear to occur in similar relative proportions across the excavation areas, units, and levels.

Table 7.7. Frequency of blade termination morphologies.

Termination	Area 1		Area 2	
	n	%	N	%
Feather	175	53.68	123	56.94
Plunging	59	18.10	39	18.06
Hinge	92	28.23	54	25
Total	326		216	
<i>languette</i>	81		39	

7.4 Other production errors

As outlined in Chapter 5, weighted tallies of errors were calculated for each individual proximal and complete blade. Production errors could be related to termination, the presence of step or hinge fractures on the dorsal surface, platform damage, or metric ratios that were outside two standard deviations from the mean. Evidence of errors was relatively high, with 46% of all blades having evidence of either production errors (e.g. hinge terminations, shattered platforms), or evidence of previous production errors on the dorsal surface (Figure 7.18). Only 11% of blades had evidence of multiple errors.

Analysis of error frequency and average error values consistently show an increase in error rates through the reduction sequence such that the smallest blades have higher rates of errors. Blade length has the most nuanced pattern, with a spike in error rates occurring at lengths of around 75-80mm, with a consistently higher error rate setting in after ~60mm (Figure 7.19). This does not match expectations that errors should be more common on the longest blades, with fewer errors on smaller blades. Each individual variable involved in calculating error rates, such as termination errors, platform damage, or remnant hinge or step scars, follow the same pattern of highest rates from 60-40mm blade lengths. Errors are also associated with mid-to-small platform sizes. There is also no strong association of production errors with either large or small platform size-to-length ratios. Error rates are similar across blades of high, medium, and low quality obsidians ($\chi^2 = 6.68$, $df = 6$, Monte Carlo $p = .347$). Interestingly, the lower quality obsidian blades have a higher rate of “repair” blades that remove previous errors.

A lack of platform preparation might be considered evidence of lack of skill or production effort. Surprisingly, there was no difference in error rates between unprepared and prepared platforms (Figure 7.20). Blades with dorsal-proximal faceting that extended roughly 5cm did have

a higher error rate than blades with mild DPF or unprepared platforms by about 10%. This may reflect a sign of “over-preparation” correlating with a higher likelihood to incur errors.

One possible correlation with skill may exist when error rates are analyzed against blade length: thickness ratios. The highest “skill” blades, those which are the longest and thinnest, have the lowest rates of errors. As blades become thicker and/or shorter, error rates gradually increase ($\chi^2 = 13.28$, $df = 6$, Monte Carlo $p = .039$).

Figure 7.18. Common forms of production errors. (A) Stacked step fractures; (B) hinge termination and opposed dorsal step fractures; (C) two step fractures; (D) peeled erailure terminating with a languette break; (E,G) Shattered platform with peeled erailure; (F) Languette break.

Figure 7.19. Average error rates across the blade reduction sequence. Error bars represent 1 sigma standard error.

Figure 7.20. Blade error rates by platform preparation (left) and blade length:thickness ratio (Right).

Another correlating variable is curvature, although this is itself associated with blade length (see above). One possibility is that decreasing curvature through the reduction sequence leads to increasingly steep platform angles, which make successful blade production more difficult. As discussed above, there are high rates of platform rejuvenations and core modification flakes that suggest significant efforts to prevent these kinds of problems.

7.6 Non-blade flake debitage

Non-blade flakes from the Elmenteitan Obsidian Quarry generally fall into one of three categories. First, many flakes are certainly products of the flake core reduction discussed above. A large portion of the flake assemblage could be related to core preparation and modification, although they lack any obvious platform removals or other features that would allow them to be readily identified as such. As is the case for debris that is clearly core preparation, platforms on flakes are overwhelmingly large (on average twice the size of blade platforms), and unprepared. Additionally, these categories show no patterning in terms of flake scar orientation, flake scar count, or general morphology. Finally, a small portion of the flake assemblage may reflect failed attempts at blade removals. This last category may account for the 9% of flakes that do demonstrate platform preparation. Flake debris is generally small, with few pieces over 60 mm in maximum length, far less than is the case for technical blades.

Plain, unmodified, platforms are by far the most frequent type for both flakes (81.7%) and core preparation debris (71.8%). The ratio of cortical or faceted platforms to typical Elmenteitan abraded and dorsal-proximally faceted platforms is also much higher in these categories. Platform preparation thus appears largely restricted to intentional blade production. Platforms in the flake and core modification categories are on average two-to-four times larger than they are for the

blades. Cortical, faceted, and plain platforms seem to reflect early stage nodule preparation and core reduction. This is supported by the typical association of large flat platforms with hard-hammer reduction, which is better suited to early stage testing and reduction (Dibble and Pelcin 1995).

Figure 7.21. Pie chart of error score (# of errors) on blades from GsJ50 assemblage, showing that 41% of blades at the site have uncorrected production errors. Blades with multiple production errors are less frequent than blades with one or two errors.

7.7 Patterns in core preparation and reduction

The lithic assemblage recovered from the Elmenteitan Quarry Site reflects both a high rate of core production, as well as intensive blade reduction. Evidence for specialized core morphologies is minimal, and the preference appears to be for keel shaped cores with a single blade reduction face. A second, alternated platform is sometimes added later in the reduction sequence. There is also a wide range of expedient and informal cores that reflect in-situ reduction rather than preparation of cores for transport, exchange, or distribution.

Very large (>15 cm) early stage blades are present, however the majority of the blades assemblage falls into the 4-7 cm range. Blades show a greater range of morphometric diversity throughout the reduction sequence than is known from other Elmenteitan sites. Different technological attributes appear to change at a few key points in the blade reduction sequence (see Table 7.8). Many aspects of classically Elmenteitan blades are established at blade lengths of around 80 mm. Subsequent changes in core style, flake scar count, and error rate appear to change later in the sequence, closer to blade lengths around 50 mm.

Intra-site comparisons reinforce the behavioral differences in lithic reduction between Areas 1 and 2. Important dimensions of Elmenteitan blade production, like the application of dorsal-proximal faceting, the manufacture of flat blades, and keeled cores (see C. Nelson 1980) are evident in both areas. Other technological signatures like core types, flake scar counts and directionality, and average blade length, are also roughly consistent across the site. Differences seem to be of degree, rather than kind. Unprepared platforms are more common in Area 2, and this area has a much higher incidence of low quality obsidian, angular shatter, and early stage debris.

Table 7.8. Evidence for changes in core design through the operational sequence.

Evidence	Core design change	When transition occurs (by blade length)
Cores	Shift from “faced” cores to other types	~50 mm
Dorsal-proximal faceting	Applied consistently	90-80 mm
Platform size	Consistently small platforms	80 mm
Flake scar directionality	Consistently parallel	75-70 mm
Flake scar count	Consistently 2-3 dorsal scars	45 mm
Flake symmetry	Straight (no bend)	~70 mm
Curvature	Flat or nearly flat	80 mm
Cortex	High cortex rates	>100 mm, 60-40 mm
Errors	High error rates	~80 mm, <55 mm
Bulb size (i.e. technique)	Shift from hard hammer to punch	~150 mm

Chapter 8

RESULTS III: COMPARATIVE ANALYSIS OF ELMENTEITAN TECHNOLOGICAL ORGANIZATION

This chapter presents the results of a comparative analysis of Elmenteitan blade assemblages designed to define the regional variation within Elmenteitan core reduction strategies. Here, I apply all of the metric analyses and measures of platform type and size, flake scar orientation and count, blade symmetry and curvature, rates of cortex, termination types, and error quantifications applied to the Elmenteitan Obsidian Quarry to 11 additional Elmenteitan sites, and the SPN outgroup sample of Narosura. I use select continuous measures within a Principal Components Analysis, and then, subsequently, variation in each attribute listed above is presented and described individually. The goal is to build a quantitative description of the Elmenteitan techno-group, and identify if there is meaningful variability in any attributes, or sets of attributes, at individual sites, regions, or time periods.

8.1 Blade metrics⁴

8.1.1 Length

Blade length is the best available proxy for blade core size and utility at Elmenteitan sites where raw material homogeneity prevents minimal analytical nodule analysis. At GsJj50, several blade shape variables and attributes have clear relationships with overall blade size, and so documenting blade length distributions is important for interpreting subsequent variation. Length is presented in two ways, by the length of the longest blade in an assemblage (Figure 8.3) and the

⁴ All figures in the following sections use site abbreviations given in Table 5.4 (pg.140). Please refer to that table and Figure 5.9 (pg. 141) for site locations, dates, and sample sizes for all results presented below.

average blade length in an assemblage (Figure 8.4). Assuming that the largest blades will have lengths at, or near, the maximum height of the core, that measure can be used to estimate the largest possible core size brought to a site. Average blade length provides a time-averaged assessment of core access and tracks intensity of core reduction. Both measures show the same overall pattern of a non-linear decrease in blade length with distance from the quarry site. There is no evidence for fluctuation in blade length through time based on the available dates for the sampled assemblages.

Considering only the longest blades per assemblage, there appear to be two “tiers” of core access. Sites within ~100 km have access to cores over 12 cm in maximum dimension, whereas sites between 100 and 250 km appear to be receiving only cores between 12-10 cm, based on maximum blade size and as estimated using widths and thickness from segments (following Goldstein [2014]). Within the first tier, which includes all Central Rift Valley burial and habitation sites, the open-air settlement of Remnant on the Mau Escarpment, and the site of Ngamuriak in the Lemek Valley, the maximum blade length has a consistent cap at around 12-14 cm. The rockshelter site of Njoro River and Enkapune ya Muto, and the open air site at Remnant demonstrate somewhat lower maximum blade sizes, however this could be due to either sampling, normal variation in core sizes, or differential access between these sites. In any case, the largest cores reaching these sites were also at least 10 cm long in their maximum dimension.

Those sites at a greater distance (Olopilukunya in the Loita Hills, and Wadh Lang’o, and Gogo Falls near Lake Victoria) are consistent in having maximum blade sizes at around 80mm. There is between a 2 and 6 cm difference in the size of cores that are being transported beyond 100 km from the quarry site. Such a difference could be considered to be minor, but the consistency of that signature across the sampled sites suggests it is a behaviorally significant pattern. No site

appears to be receiving cores under about 10 cm regardless of distance, which strongly implies consistent distribution of cores of that size.

Figure 8.1. Length of the longest blade per sampled site by distance from GsJj50.

Figure 8.2. Average blade length per sampled site by distance from GsJj50. Error bar ranges= 2σ from the mean. Shaded area represents 2σ range for blades produced at the GsJj50 source. Note the Gambles (GAM), Bromhead's (BRM) and Suswa (SUS) samples are small and likely reflect collector/sampling bias.

Average blade lengths display a similar pattern with sites closer to the source tending to have blade assemblages that are longer overall than sites further from the source. The distance decay pattern is more gradual, with Ngamuriak appearing somewhat transitional between the <50 km and >120 km groups. [Note that while the Suswa Lava Tube sample has a high average blade length, it is a surface collection and likely is heavily biased toward larger blades]. If anything, it appears that average blade size is increasing with distance at sites up to 60 km from the quarry before beginning to decrease around 100 km. As with maximum blade size, the pattern for the closer sites is more variable, whereas the more distant sites demonstrate a more consistent average and distribution.

Discrepancies between largest blade size and average blade size can be used to reconstruct core reduction intensities. For example, although Enkapune ya Sauli has a single blade over 14 cm (suggesting presence of larger cores) the remainder of the blades in the assemblage are under 10 cm, with a much lower average at 4.69 cm. This contrasts with the nearby site of Enkapune ya Muto, where Elmenteitan levels sampled have an average blade size of 7.63 cm, despite having a maximum blade size of only 10.2 cm. Comparisons between the habitation sites of Remnant and Ngamuriak also reveal divergences in blade size patterns. Smaller cores were being transported to Remnant, but there is a smaller divergence between average maximum and average blade lengths there than at Ngamuriak, where large cores were being reduced more intensively. As with maximum blade length, average length at the three most distant sites is stable at ~50 mm, with no further distance-decay between 100 and 250 km.

Distance appears to be the most important predictive variable for blade length, and thus core size, but that correlation is only moderately strong (Spearman rho: $r^2 = .66$, $p = .03$). As demonstrated in Figure 8.4, none of the sampled sites within 250 km from the source show an

intensity of reduction that falls below the 95% confidence interval for blade length variation at quarry itself. Average blade length at any Elmenteitan site, regardless of distance, is likely to be less than 2 cm from the average at the GsJj50 point-of-origin. Site-to-site variation within what is otherwise a fairly stable pattern of blade lengths may be due to a number of factors.

8.2.2 *Cross-sectional area*

Blade cross-sectional area (blade width x thickness) is another important measure of blade morphology driving variability between sites, as demonstrated by PCA results. Controlling for cross-sectional area in blank production may be desirable to help produce consistent blanks for tool production. Given the common practice of blade segmentation amongst the Elmenteitan (see C. Nelson 1980 and Ambrose 2001), cross-sectional may be especially technologically relevant. Not surprisingly, the Elmenteitan Obsidian Quarry sample has the highest proportion of the widest and thickest blades. In general, blade cross-sectional area tends to decrease with distance from the quarry site. Enkapune ya Muto and Enkapune ya Sauli, the two rockshelter sites on the western Mau Escarpment, are the exceptions to this general trend with similarly lower median and average values and distributions. Cross-sectional area tracks with blade length, and this can account for the generally thinner blades at distant sites like Olopilukunya, Gogo Falls, and Wadh Lang'o.

Blade cross-sectional area may be partially tied to blade length, however site specific circumstances contribute to deviations from this trend. Neither raw material access nor imposed design can fully explain the cross-sectional area pattern. The Elmenteitan comparative mortuary and habitation sites studied here may suggest an overall desire for consistently thinner blades, which is relaxed and/or obscured at the quarry site due to the production of so many large, early stage, blades. It is less clear why the Remnant site and Elmenteitan deposits at Gamble's Cave

should have such a higher rate of thick blades, especially considering they represent two extremes of mean blade length range for all Elmenteitan sites.

Whatever variables are affecting variation in blade cross-sectional area, it is not likely related to Elmenteitan-specific technological strategies. Narosura, the outgroup SPN sample, has a distribution that groups well within the Elmenteitan range. As with length blade length, specific ecological conditions or circumstances of raw material access in place and time may be influencing blade production strategies.

Figure 8.3. Blade cross-sectional area for Elmenteitan sites. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry.

8.2.3 Length-to-Thickness

Blade length-to-thickness ratios are an alternative view of the metric patterns presented above. Elmenteitan sites length:thickness ratios have a bi-modal distribution, with some having high values, and other sites having low values. Just as with length, both Enkapune ya Sauli and Remnant display very low length:thickness values. Therefore blades at these sites are not simply

shorter, but thicker as well. Gogo Falls and Wadh Lang'o, both located in the same Lake Victoria region with similar occupation chronologies, also have significantly ($p > .05$) different length:thickness distributions, with the Wadh Lang'o blades being much thinner. Distance from the quarry site may play some role in structuring the overall patterns in cross-sectional area, but raw material supply alone is responsible for metric relationships. There is preliminary evidence that herders were using different technological approaches at these sites. Narosura again groups within the Elmenteitan range of variability, however it is toward the lower, thicker, end of the Elmenteitan range.

8.3 Striking platforms

8.3.1 Striking platform preparation

Outside of the quarry, Elmenteitan assemblages are dominated by blades with the dorsal-proximal faceting (DPF) form of platform preparation. When combined with the “point” platform class (platforms too small to measure, typically due to intensive preparation), this strategy of platform preparation accounts for between 50-80% (100% in the small Suswa Lava Tubes sample), of all platform bearing blades from the sampled Elmenteitan sites. Grinding and faceting are both rare overall. The high representation of platform faceting at Lion Hill Cave may be attributed to small sample size, however the 25% rate at Bromhead's Site is more robust. Likewise the higher proportion (15%) of ground platforms at Enkapune ya Muto is also somewhat unusual compared to the general pattern for Elmenteitan cave and open-air sites.

Average and maximum blade sizes were nearly identical between Olopilokunya, Wadh Lang'o and Gogo Falls, however these sites show some divergences in platform attributes that are

relevant for discussing raw material access. Namely, point platforms are much more frequent (~60%) at the two Lake Victoria sites, Gogo Falls and Wadh Lang'o.

8.3.2 *Striking platform size*

Smaller platforms are the Elmenteitan norm, and maintaining small striking platforms is largely a result of the more consistent application of dorsal-proximal faceting (Figure 8.6). There are some deviations, and these mirror some patterns already noted morphometrically. For example, Enkapune ya Sauli and Remnant, where blade length was overall lower, have both the highest average platform surface area and the widest distribution of platform sizes outside of the quarry site. Platforms at Ngamuriak are larger than average as well.

Viewing all samples from all Elmenteitan sites together, it is clear that platform size is not a good predictor of blade length (Linear $r^2 = .009$, $p = .839$), but that it is a reliable predictor for cross-sectional area ($r^2 = .71$, $p < .05$). Unlike the quarry site where the platform thickness/blade thickness to platform width/blade width relationships are more stable, the linear correlation between these variables for blades at habitation sites is far weaker (Figure 8.7)

Although these may be consistent patterns overall, the site specific signatures do not necessarily match expectations. Remnant reflects the relationship between larger platforms and thicker blades, whereas the larger platform distributions at Enkapune Ya Sauli and Ngamuriak are associated with relatively thinner blades. The assemblage from Gamble's Cave is one of the overall thickest blade collections, and yet has the small platforms typical of other Elmenteitan sites. It is also not clear whether the ratios of dorsal-proximal faceting vs. other forms of preparation have any clear relationship with platform size, at least within the Elmenteitan samples.

Figure 8.4. Blade length-to-thickness ratios at the sampled sites. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry.

Figure 8.5. Proportions of striking platform preparation style at sampled sites. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry (not counting Narosura).

Platform preparation does, however, provide one of the clearest lines of evidence for distinguishing Elmenteitan from the outgroup Narosura sample. The SPN site is dominated by heavily ground and abraded platforms, with less than 10% of blades showing platform preparation that extends onto the dorsal surface. There were also no true point platforms in the Narosura sample. Most platforms are still small, and have a relatively narrow distribution around 36 mm². As a result, the Narosura outgroup sample has somewhat larger platforms than most Elmenteitan sites, but is well within the range of the aforementioned “large platform” Elmenteitan sites. Blades from Narosura are not graphed on Figure 8.7, however these values are entirely within the range of Elmenteitan blade assemblages. Additional data on striking platform size across sampled sites is given in Appendix III: Table 1, and Appendix IV: Figure 1.

Figure 8.6. Striking platform area (mm²) at sampled sites. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry.

Figure 8.7. Biplot of platform width and thickness to blade wide and thickness for all Elmenteitan comparative sites (Narosura excluded). Blue line represents linear regression ($r^2=.34$, $p<.05$). Compared to the same regression at the Elmenteitan Obsidian Quarry (Figure 7.14), the metric relationships between platforms and blade metrics are less regular.

8.4 Flake scar directionality

Flake scar directionality is a second variable that is relevant for understanding core design and appears strongly tied to assemblage group within the samples analyzed here. Overall, Elmenteitan assemblages reflect a preference for unidirectional, or “parallel” flaking strategies (Figure 8.8). This contrasts with Narosura and other SPN sites (personal observation), where bi-directional flaking is more common.

At all sites except for Remnant, parallel flaking describes over 70% of the blades from any site, including the quarry where there was significant evidence of frequent core rotations and

platform readjustments during core preparation (see Chapter 7.7). Within the Central Rift, 85-100% of the blades exhibit parallel flaking. Rates of bi-directional and alternated flaking strategies increase with distance from the quarry (Figure 8.8). Remnant is an obvious exception, with relatively higher rates of radial and bi-directional flaking. With the exception of Remnant, parallel flaking appears to be a design element imposed on cores early in the production sequence at the quarry, and which is maintained at sites in different ecologies across southern Kenya.

8.5 Flake scar count

Elmenteitan sites from the quarry through to the most distant sites at Lake Victoria maintain consistent flake scar count distributions that are normally distributed around a mean of three dorsal flake scars (except for Area 2 of the quarry where earlier stage blades have fewer flake scars) (see Figure 8.9). This contrasts with the Narosura sample, where there is a more even distribution of blades with 2-4 dorsal flake scars. Remnant and Ngamuriak are again atypical in that they have higher ratios of blades with five or more dorsal flake scars. The proportionally higher rates at Gogo Falls and Wadh Lang'o may be attributed to smaller cores with sharper angles, and thus fewer intersections with previous removals.

As is the case with flake scar directionality, the patterns in flake scar counts reflects general consistency in blade reductions strategies across Elmenteitan sites. This begins to break down at the most distant margins of the Elmenteitan network, but still offers an apparent contrast with the strategies at the SPN site of Narosura.

Figure 8.8. Flake scar directionality at sampled sites. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry.

Figure 8.9. Flake scar count by site. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry.

Figure 8.10. Blade curvature by site. Curvature closer to 180 reflect flatter blades, lower values reflect higher curvature. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry.

8.6 Blade curvature

The pattern of flatter blades at Elmenteitan sites relative to SPN sites noted by C. Nelson (1980) and Ambrose (2001) is supported by the quantitative measurements of blade curvatures (Figure 8.10). Only Lion Hill Cave and Njoro River Cave have median and mean curvatures that are greater than 10 degrees away from being effectively flat (i.e. curvatures > 170 degrees). Lion Hill Cave is a smaller sampler and so this reading may be due to sampling error, however the Njoro collection is more substantial and thus may reflect a real, albeit slight, variation from the Elmenteitan pattern. It should be noted that both Njoro River Cave, and Gamble's Cave II (which has mean values close to 170 and a similarly high curvature distribution) are specialized burial sites. The sample from Bromhead's Site was too small to include in this analysis, and so more data from additional sites are needed to determine if this is a consistent feature of Elmenteitan special purpose sites.

8.7 Cortex

Rates of cortical coverage on blades at Elmenteitan sites does not follow the expected pattern for down-the-line exchange wherein dorsal cortex rates diminish with distance from the quarry. Figure 8.11 tracks the average percentage of cortical coverage ratios on blades in analyzed assemblages (e.g. a score of .1 means the average blade as 10% dorsal cortex).

According to this measure, rates of dorsal cortex appear to be remaining constant, if not slightly increasing, with distance from the quarry site. Following the de-cortification pattern at the quarry (see Chapter 7), this may indicate smaller cores were transported greater distances. Again, we would expect that cores are reduced as they are curated, and in the process cortex is gradually lost as the core is transported across the landscape. Instead, rates of cortex at the source are unexpectedly low compared to more distant sites like Ngamuriak, Olopilokunya and Gogo Falls in western Kenya (although no blades at Wadh Lang'o had dorsal cortex).

Figure 8.12 plots the ratio of dorsal cortex on blades by the blade length for all Elmenteitan sampled specimens with dorsal cortex (excluding quarry samples). This suggests that earlier blade removals have very little (< 20%) dorsal cortex, but blades between 60-40 mm tend to have the greatest amount of dorsal cortex, and have higher frequencies of dorsal cortex. Blades with high cortex are not the longest blades at their respective sites. These results are similar to those described in Chapter 7 for the Elmenteitan Obsidian Quarry, indicating it is an element of a Elmenteitan core-design and reduction strategy being implemented at the quarry, and repeated or maintained at Elmenteitan special purpose sites and habitations.

Figure 8.11. Average dorsal cortex coverage by site. Error bars represent one sigma standard error. Sites plotted left-to-right by distance from the Elmenteitan Obsidian Quarry.

Figure 8.12. Dorsal cortex coverage ratio (0-1) by blade length for all blades from comparative Elmenteitan sites.

8.8 Quantifying obsidian access

Using combinations of the metrics discussed above, it is possible to develop correlations for relative “access” to obsidian. The two most important variables I chose are blade size and platform area. Maximum blade size reflects the largest core size that people brought to a site, and the difference between maximum blade size and average blade size provides a rough estimate for the intensity with which they reduced cores. The larger that difference, the more intensively cores at that site were reduced. Larger platform areas reduce the usable volume of a core more quickly by producing thicker blade products that will more quickly deplete a core (although see discussion of blade segments-as-cores in Chapter 9). Accuracy of this method improved under the assumptions that the number of cores represented at a site or in a horizon was relatively low, that the excavated sample is an accurate representation of the entire site/horizon, and that the assemblage was not palimpsest of different occupations and activity patterns. It is difficult to evaluate these assumptions for many of the sites, and the model presented here is intended to be just that; a model to be tested and evaluated with continued analyses of samples at more sites.

Figure 8.16 demonstrates that there is a very strong positive correlation between core reduction intensity and platform area (Pearsons $r^2=.83$, $p < .05$). This suggests that sites with the largest core reduction intensity demonstrate the least effort to conserve raw material. Therefore, one possible effective method for quantifying the regularity/dependability of obsidian access is look at the relationship between these variables. Following this approach, obsidian access might be visualized in Figure 8.13 as tracking from the least consistent access at the bottom left to highest access at the upper right. The Elmenteitan Obsidian Quarry would therefore reflect the highest access (as expected) and the most distant Lake Victoria sites (and Lion Hill) display the lowest access rates.

It is important to note that this is only a rough correlation, and will be biased by variation in obsidian access across time/phases of site occupation. Additionally, there is a complicated relationship between actual access to obsidian and the expectations for future access to obsidian reflected in the archaeological assemblages. Nevertheless, it is possible to display these relationships spatially.

Figure 8.13. Relationship between proxy for core reduction intensity and average platform area for Elmenteitan sites (triangles= Central Rift sites, squares= Mau/ southwestern highland sites, diamonds= Lake Victoria sites). Error bars represent one standard error.

Core reduction intensity values and platform size ranges can then be inserted into an interpolation spatial model following natural neighbor assumptions that assume obsidian access is related to proximity to other sites of a known access rate. Other interpolation methods (e.g. Inverse

distance weighting (IDW)) may be more accurate if access is site-specific rather than regionally dependent, but data density is not high enough for such models to be accurate.

The generated interpolation map is given in Figure 8.14. As evident in many uni-variate analyses presented above, while there is a definite role of distance from the quarry in obsidian access, the overall pattern is clearly being shaped by more complex spatial/temporal factors.

Figure 8.14. Interpolation map of relative access to obsidian at Elmenteitan sites in southwestern Kenya. Model uses a Natural Neighbor interpolation. Data used in the model is given in Appendix III-C.

8.9 Production error rates.

Error rates could only be quantified for eight of these samples due to constraints in sample sizes. Therefore the following section includes only Enkapune Ya Muto, Remnant, Njoro River

Cave, Ngamuriak, Olopilukunya, Wadh Lango, and Gogo Falls. These are compared to a pooled sample of the error rates from the Elmenteitan Obsidian Quarry (GsJj50).

There are no clear relationships between the rate of production errors in the assemblage and distance from the quarry site. The quarry assemblage does have a high rate of production errors relative to most Elmenteitan sites, however both the Remnant Site and Njoro River Cave have even higher error rates (Figure 8.15).

High error rates quantified here mirror the observation that the Njoro River Cave assemblage is “degenerate” and “poorly made”, while still being markedly Elmenteitan (Leakey and Leakey 1950:74). Njoro Rive Cave is a specialized mortuary site, and it is not evident that the lithic assemblage derived from a habitation episode, although Leakey and Leakey (1950) suggest much of the assemblage may have been manufactured elsewhere and transported to the site. Blades may have been produced *in-situ* for tasks relating to cremation and burial, they may have entered the site as personal toolkits of the deceased, or some combination. Error rates at the Remnant Site can be reasonably attributed to production mistakes during the site’s occupation, possibly by novices. This raises a very important question of whether the high error rates at the Remnant Site are related to its atypical signatures for many of the variables reported above (flake scar patterns, platform size, blade size, curvature).

Omitting these sites, there appears to be a general decrease in production errors with distance in southwestern Kenya and the Loita-Mara, and then another increase at the Lake Victoria sites of Gogo Falls and Wadh Lang’o. It is possible that this could reflect increasing concern for raw material utility, with the higher rates at the most distant sites being a product of the much smaller cores being reduced at these sites. Platform angles become more difficult to manage at

smaller core size, and so the higher rates of errors may, in part, simply reflect the difficulties of small-blade production.

Figures 8.16 presents the ratios of types of production errors at these sites. The rate of blades that are either very thin or very thick relative to their length remains low across all sites, reflecting the fairly uniform nature of Elmenteitan blade production observed in the above sections. Platform shattering and bulbar sheering (results of a mis-aligned punch during blade removal), typically accounts for only 15-20% of production errors. The apparently higher rate at Olophilukunya reflects the small number of blades with errors in this assemblage (see Figure 8.17). The rate of blades with hinge or *languette* terminations is the only error type that clearly decreased with distance from the quarry site. This most likely correlates with core size, with larger blades being harder to detach without termination errors.

Figure 8.15. Average production error score for the sampled Elmenteitan assemblages. Error bars reflect one standard error. Sites plotted left-to-right by distance from Elmenteitan Obsidian Quarry.

Figure 8.16. Error rate classifications. Sites plotted left-to-right by distance from Elmenteitan Obsidian Quarry.

Figure 8.17. Proportions of blades with no errors, single errors, and multiple errors in the sampled assemblages. Sites plotted left-to-right by distance from Elmenteitan Obsidian Quarry.

The rate of errors on individual blades is important for relating error rates to production “skill”. This data (presented in Figure 8.20) demonstrates that the high error scores at Njoro River Cave and the Remnant Site are driven by the fact that 45-50% of blades in these assemblages have two or more production errors. At Njoro in particular, only 16% of blades have no evidence of production errors. Aside from these two sites, the other assemblages are not significantly different from the error pattern at the Elmenteitan Obsidian Quarry (GsJj50). Most sites studied had ~25-30% of blades retaining evidence of a single error and 20% or less having evidence for multiple production errors. Contrary to expectations of the “Bradbury bias” the quarry site assemblage actually has very low rates of production errors or mistakes.

8.10 Summary

Comparative analysis of Elmenteitan assemblages is necessary in order to contextualize technological patterns at the Elmenteitan Obsidian Quarry and to outline the quantitative and qualitative variation within Elmenteitan blade production strategies as a whole.

The first major pattern revealed by comparative analysis is that the technological patterns shared by Elmenteitan blade assemblages are also present, and likely first imposed, at the quarry site. Very few attributes, like striking platform type and size, are atypical at the quarry site. All other metric attributes (curvature, blade cross-sectional area, length:thickness, flake scar characteristics) present at the quarry are close to the overall median values for other Elmenteitan burial and habitation sites. Average blade length is no exception, meaning that the intensity of blade reduction at the quarry resembles that at rockshelter and habitation sites. Although the rate of production errors is relatively high at the quarry, the proportion of multiple mistakes is low and

most of these are termination errors likely related to the very large size of cores there. The appearance of errors, dorsal cortex, and other signs of core readjustment around 60-40 mm across all sites, including the quarry, suggests a shared strategy for managing core morphology through the reduction sequence. Taken all together, blade production strategies at the Elmenteitan Obsidian Quarry mirrors that of the Elmenteitan regionally, rather than reflecting only early stage nodule preparation.

Analyses presented here support the assertions of C. Nelson (1980) and Ambrose (2001) that the Elmenteitan is a cohesive technological entity. Curvature, platform preparation type, flake scar count, and flake scar directionality are particularly consistent in Elmenteitan blade assemblages and represent a technological strategy of core reduction that differs from the strategies at the SPN site of Narosura. Many more SPN sites must be analyzed in order to confirm that these are differences between the SPN and Elmenteitan are widespread. Within the Elmenteitan, it is interesting that variation does not pattern by site type (rockshelter vs. open air), site function (burial vs. settlement), date of occupation, or region. Variation from the general Elmenteitan patterns appears to be site- and attribute-specific (Table 8.3). Only the Remnant Site blade assemblage had significant differences from the other sites across multiple measures.

Table 8.1. Sites that appear to deviate from ‘typical’ Elmenteitan technological patterns by attribute.

Attribute	Sites
Average blade length	Enkapune ya Sauli, Remnant
Blade cross-sectional area	Gamble’s Cave II?
Length:thickness	None
Striking platform type	None
Striking platform area	Enkapune Ya Sauli, Remnant, Ngamuriak
Flake scar directionality	Remnant
Flake scar count	Remnant?
Blade curvature	Lion Hill, Njoro River Cave, Gamble’s Cave II
Dorsal cortex	Olopilokunya?

Chapter 9

ELMENTEITAN TECHNOLOGICAL ORGANIZATION: MOBILITY AND ECONOMY

This chapter addresses the technological organization (TO) of the Elmenteitan as reconstructed through the comparative analysis presented in Chapter 8, and other published research on Elmenteitan tools and industries. First, I discuss the theoretical approach for TO studies and evaluating measures of learning, assessing the underlying assumptions necessary to apply this model in the context of mobile pastoralism. As this study uses multiple individual variables relevant to core design rather than a tool-based TO approach, I discuss each variable and attribute in terms of how useful or productive it was in generating overall results, and where there are potential areas for improving the metrology. Understanding strengths and weaknesses in the approaches, I present a comprehensive schematic for Elmenteitan technological organization. Finally, I discuss the technological patterns in terms of their relevance for reconstructing broader Elmenteitan economic strategies and mobility.

9.1 Approaches, methods, and measurements

9.1.1 Analytical approach

As originally outlined by M. Nelson (1991) studies of technological organization (TO) are concerned with both the economic and social strategies that affect the manufacture, use, transport, and discard, of stone tools. In practice, the economic dimensions of mobility, raw material access, tool design, and curation have dominated discussions (Andrefsky 1994a,b , 2001, 2011; Bamforth 1986, 1991; Carr 1994; Cowan 1999; Goodale and Andrefsky 2015; Kuhn 1991, 2014; Lycett and Cramon-Taubadel 2015; McCall 2012). This is largely to do with practical realities of studying

prehistoric foragers. There is often little other data with which to reconstruct the ‘social’ dimensions of lithic technology (but see Slater 2016).

Results of the economic focus have been twofold. First, there has been overwhelming preference given to environmental constraints on technological strategies, as evidenced by the growing popularity of behavioral ecology in lithic interpretations (Goodale and Andrefsky 2015; Kuhn and Miller 2015; Surovell 2012). Second, the methods and approaches developed to quantify lithic technology contain implicit assumptions about the structure of raw material access, material transport costs, subsistence economy, and mobility strategies. It is difficult to generate expectations for how mobile-pastoralist structure technological strategies, or how technological signatures are affected by the existence of social exchange networks, communities of practice around lithic extraction, or donkey-assisted transportation.

Taking these factors into consideration, the discussion of Elmenteitan TO presented here operates under several assumptions that deviate from typical expectations for hunter-gatherer contexts. First, I assume raw material access is primarily related to access and participation in regional exchange (Ambrose 2001; Goldstein 2014). Tool and core curation rates are therefore not driven primarily by group mobility relative to raw material sources. Second, intensities of production of specific tools, tool morphologies, or patterns of tool-use, do not necessarily reflect variation in mobility. This is best exemplified by microlithic industries, which vary by form between different culture groups (Ambrose 2002), and which likely have functions not *strictly* related to subsistence strategy like herd protection and inter-personal violence (Goldstein and Shaffer 2016). Third, patterns of core reduction and blank production are the dimensions of PN technology most likely to reflect economic responses to environmental conditions. These

assumptions are based on interpretations of the available data, and if future studies invalidate any part of them, the TO model presented here will require revision.

The approach of this project uses blade blank attributes and measurements as a proxy to reconstruct core design and reduction strategy. As stated above, this is largely because core reduction is likely the most promising avenue of research for generating meaningful data on early pastoralist TO. This approach is also favored because blade blanks represent a much larger dataset than cores themselves (which are extremely rare in the PN archaeological record), or any individual class of tool (see Goldstein 2014).

9.1.2 Methods

I recorded 14 individual variables for each complete blade specimen sampled; length, width, thickness, weight, platform width, platform thickness, platform type, curvature, dorsal features, scar count, scar pattern, symmetry, termination type, and cortex. Different sets of variables were more relevant for comparisons across culture groups, comparisons between Elmenteitan sites, and reconstructing production sequences. In some cases, specific measurement strategies or attribute classifications proved problematic, and these are discussed below within a review of measurements.

Sampling: Without having established variances across different measurements, it is impossible to know what sample size is needed for high statistical power. Unfortunately, the general range for many variables is in the range of 50-100 individual blades, which is far more than are available from most sites. Given that there is no precedent for this type of analysis on PN assemblages, I think that the inclusion of very small samples is justified because it allows a more regionally comprehensive picture of Elmenteitan technologies. This does come at the cost of

accuracy and precision of the results. Essentially, I argue that building a broad testable TO model that can be refined through future excavations and analyses is more important than presenting a limited, but more precise, model.

Metrics: Length, width, thickness, and weight are fundamental measures of all lithic artifacts and are necessary for basic comparisons. In this study, a focus on the blade as a proxy for the core necessitated taking “technological” lengths for blades- which is measured as the extent of the blade as perpendicular to the striking platform. In some cases this differs from the maximum length of the blade, such as when blades are asymmetrical or “twist” to one direction. A preference for technological lengths ensures that the measurement is an accurate representation of the height of the core rather than the path of the blade. Core height became an extremely important measure in several analyses, and was the baseline for identifying modifications to core morphology through the reduction sequence. It was also important for understanding the distribution of error rates within the assemblage. A measurement strategy based on maximum blade length may have ended with different results, which I argue could result in misclassification of a blades place in the reduction sequence.

Platforms: Quantification of platform preparation styles confirms the strong assertion that preparation techniques vary by culture group (see Ambrose 2002). Dorsal-proximal faceting dominates all Elmenteitan assemblages, but it is not universal and there are variable rates of ground, faceted, and plain platforms. Platform area (platform width and platform thickness) continue to be useful, as these highlight interesting variation within the Elmenteitan.

Curvature and symmetry: Curvature is by far the most problematic measurement (see Andrefsky 2005). The measurement technique used here is fairly easy and replicable, but does not factor in the distribution of curvature along the blade length. For example, a blade with gradual

continuous curvature from a pyramidal blade core and a blade that is very flat but with a sudden and extreme distal curvature are very different from a technological perspective, but yield the same curvature value. It may be more accurate to consider blades where curvature is only distal or proximal as effectively ‘flat’. That was not done in this study, and so the curvature measures may skew toward higher values. Despite these problems, curvature is an extremely important variable for comparing different Elmenteitan sites, and comparing the Elmenteitan with the SPN (Ambrose 2001). The value of the correlate may be worth the flaws in the measuring technique. Future applications of 3D metrology may help rectify this problem, though that solution is far from practical at present. Blade symmetry did not ultimately prove to be a useful measure for inter-site comparisons, but does help demonstrate that core designs minimized opportunities for asymmetrical blades.

Dorsal features/ terminations: Both quantification of dorsal errors and blade terminations proved to be essential measures in assessments of error rates and “skill” within this study. Assessing dorsal errors has an inherently qualitative dimension; how does one weigh a single dorsal step fracture relative two dorsal step fractures, relative to three or more? I found the strategy of simply recording “single errors”, “2 errors”, and “multiple errors”, to be an efficient solution, and it is unclear if more nuance would add understanding.

Scar count and scar pattern: Scar pattern may be an important dimension of Elmenteitan technology relative to that of the SPN, with a greater degree of bi-directional flaking in the latter assemblage group. Likewise, there is some evidence that distributions of scar counts is very consistent within the Elmenteitan, and may differ from the SPN.

Cortex: The use of a ratio system rounded to the nearest 10% for measuring dorsal cortex (following Andrefsky 2005) proved useful for highlighting variation in cortex through the

reduction sequence. Use of a lower resolution measure (e.g. “primary”, “secondary”, and “tertiary”) would have obscured this variation.

9.1.3 Learning and skill

Identifying learners in the archeological record, and being able to segregate artifacts with the intended ‘idealized’ form from low-skill attempts is important for building accurate models of technological organization. This study follows recent attempts to quantify skill and learning by identifying several indicators of high and low skill (Bamforth and Finlay 2008; Eren et al. 2015; Lassen and Williams 2015; Lycett et al. 2015; Milne 2005). The approach here differs from previous approaches in that instead of calculating mistake ratios for each variable, all identified mistakes were scored, tallied, and per-site ratios were calculated. The critical assumption here, and in fact in all studies, is that the frequency of mistakes reflects skill of the knappers (Bamforth and Finlay 2008; Finlay 2015). It is worth re-iterating that even high skilled individuals need not apply that skill at all times, especially in contexts of raw material abundance (Grimm 2000; Stout 2002).

The method applied here provides a coarse measure of skill that is useful for comparing two contexts or assemblages. A logical next step would be to pursue refit studies within the high-skill vs. low-skill assemblages looking for specific core reduction events that can be attributed to an expert or novice. Direct refits remain the strongest evidence for identifying novices archaeologically (see Grimm 2000; Pigeot 1990; Sackett 1999). Due to time and logistical constraints it was not possible to conduct any refit analysis in this project, making it somewhat difficult to ascertain the degree to which difference in skill are really shaping the patterns.

Another potential problem with this method is that too much or too little weight may be given to some blade production mistakes. Both a hinge termination and a platform shattering

receive the same error score, when some features may be more or less indicative of low-skill (see experimental results in Ferguson 2003 and Eren et al. 2015). The decision to weight multiple step fractures is justified, as repeated mistakes are a stronger line of evidence for novices (Bamforth and Finlay 2008). This method also risks double counting mistakes that may be correlated- like a platform shatter and hinge termination. There were too few instances of this within the assemblages included here to significantly affect the results, although this should be assessed for any future applications. Taken together, there is a clear need for blade reduction experiments in order to test the validity of the error scoring method.

9.2. Elmenteitan technological organization

9.2.1 Raw material availability

Raw material procurement costs are perhaps the most important variables, besides environment, structuring technological organization (Andrefsky 1991, 2010; Bamforth 1986; Binford and O'Connell 1984; Gould and Saggers 1985). A diverse range of raw materials was available to PN populations, including cherts, chalcedonys, basalts, lavas, and quartz. The overwhelming preference for high quality obsidian is therefore significant, and it signals that Elmenteitan pastoralist technology prioritized dependability and predictability in blank production. Use of obsidian by Elmenteitan groups was likely driven by the emphasis on large blade production, which required homogenous material that behaves predictably (Clark 1987; Gamble 1986).

Raw material conservation is one of many benefits of blade technologies. Blade production is often favored by highly mobile communities because it allows the current raw material supply to last longer with less waste (Morrow 1987; Parry and Kelly 1987, but see Eren et al. 2008).

Ultimately though, this is probably not the motivating force for blade production within the Elmenteitan. The constraints of mobile pastoral economies make it unlikely that raw material access was embedded (*sensu* Binford 1979) within general mobility. This research supports models of obsidian access through a regional exchange or distribution. Transportability of lithic raw materials (*sensu* M. Nelson 1991), is far less of a constraint for groups with access to donkeys and other livestock that mitigate transport-energy costs (Grillo 2012; Marshall and Weissbrod 2011). Without pack animals, it is doubtful that people would have been able to maintain the peculiar Elmenteitan raw material pattern.

The ability of Elmentetian populations to forgo use of other raw materials to the extent they did suggests obsidian supply was fairly robust (Goldstein 2014), and yet there are no signs of the increased rates of expedient core reduction that is expected with raw material abundance (Bamforth 1986; Parry and Kelly 1987). Figure 5.16 demonstrates that core reduction intensity is positively correlated with platform area, meaning that at sites where people were reducing cores the most, they were either putting in the least effort to maximize the utility of the cores on hand, or were preferentially producing wider and/or thicker blades. This may seem counterintuitive, unless groups with limited obsidian supply removed blades only when necessary (resulting in less evident reduction intensity) and with carefully prepared platforms to conserve the obsidian they had on hand.

One hypothesis to be tested with more samples is that groups with abundant access to obsidian were less concerned with conservation and removed more blades with less careful platform preparation. More blades would have went unused, entering the archaeological record and giving the signature of high reduction intensity. Evidence for raw material conservation, thus obsidian access, varies across site, however technological patterns do not. Therefore, conservation

was not a major driving force for the blade industries of the Elmenteitan. Ruling that out, it is possible to begin discussing other social, economic, and environmental forces structuring Elmenteitan technological organization.

9.2.2 Raw material selection

Discussion of the Elmenteitan obsidian networks must consider the rationale for intentional preference for such a specific obsidian source. The presence of the quarry in a high altitude environment, away from regular habitation zones, highlights the difficulty inherent in accessing this particular obsidian source. Use of the Eburru sources fits well within the Elmenteitan preference for highland settlement, avoiding competition with the SPN and other groups who were using much more easily accessed sources in the Naivasha basin. Even if competitive exclusion explains the different use of these sources, it still reflects decisions being made in a social realm.

In light of new data from the Elmenteitan Obsidian Quarry presented here, quality alone cannot explain the Elmenteitan preference. Pure obsidian nodules are present, but require intensive preparation to remove cortex, internal flaws, and other heterogeneities. Elmenteitan producers appear to have been putting in considerably more effort to access a more remote obsidian source. A common explanation for such patterns in other archaeological contexts is that access to, or possession of, specific resources is associated with membership in a socially constructed identity group (Dillian and White 2010; Hughes 1978; Schortmann and Urban 2012).

Color can be a particularly important motivation for selective use of specifically obsidians. Green obsidian also occurs at the Waterloo Ridge and lower Eburru sources, and SPN groups used obsidians of a more diverse range of colors. Color cannot be “faked”, and using or possessing mostly green obsidian might have been one indicator that one was an active participant within

Elmenteitan webs of exchange and alliance. This could become symbolic for many reasons, but may be a material reflection of the economic security social exchange networks provides (see Renfrew 1985: 86; Sahlins 1972: 186). Signaling participation in the overall system would be useful to ensure reciprocity and adherence to social *habitus* between Elmenteitan individuals who are neither kin nor personal acquaintances. These possibilities are important in that they could indicate access to the Elmenteitan Obsidian Quarry (and/or the subsequent exchange) were integral in building and maintaining group identities for the people who produced Elmenteitan material culture. Certainly the connection between identity and participation in material exchange is recognized in many other contexts (Bayman 2010; Hodder 1992; Spielmann 2002). Investigating these models is necessary in order to better understand the social role of this quarry, and others, within prehistoric pastoralist lifeways in eastern Africa.

9.2.3 Reliability, flexibility, versatility

The prevalence of blade cores at Elmenteitan sites may indicate the prioritization of reliability. Blade technology emphasizes reliability by providing a consistent supply of standardized blanks (Arnold 1987, 1990). Consistency in morphology is not unique to blades themselves, but is a common trait for almost all Elmenteitan tools. Backed geometrics at Elmenteitan sites are small and much more uniform than other microlithic industries in eastern Africa (Ambrose 2002). Small microliths are also more resistant to breakage from use in either arrows or composite knives (Goldstein and Shaffer 2016), and resistance to damage is another common trait of toolkits that emphasize reliability (Gamble 1986).

Particular “Elmenteitan” style core designs outlined by C. Nelson (1980), and in the analysis reported here may reflect an even greater concern with reliability of blanks. Elmenteitan

cores utilize one or two independent sides of a core for blade reduction. The use of a single flat side instead of reduction around a curved cylindrical or pyramidal blade core prevents blades from skewing to one side, or twisting around the core. Although blades from pyramidal cores become more curved through the reduction process as core angle increases, blades from Elmenteitan cores actually become flatter through the reduction sequence. By imposing a very rigid blade core morphology, Elmenteitan groups ensured that blade blanks would be as reliably flat and straight as possible. The “naviform” type cores evident in the debitage at some Elmenteitan sites reflects an alternative strategy to accomplish the same ends of producing long flat blades (Quintero and Wilke 1995; Quintero 2010). Specialized core forms require more maintenance and management, and that higher rate of waste means they come at the cost of raw material economy (Parry and Kelly 1987). In addition, they are typically larger and less transportable (Shott 1986; Kuhn 1991).

Elmenteitan design strategies also appear to emphasize versatility and flexibility. Large blades served as versatile generalized forms that could be used to fulfil a variety of needs. Elmenteitan groups produced high rates of backed blades or used blades as expedient cutting edges rather than impose a specialized morphology that might be more efficient for a particular task. There is also evidence of flexibility (tools forms are changed to achieve multi-function needs [M. Nelson 1991:70] in Elmenteitan tools). Scrapers, one of the few formal tool at these sites, are frequently reworked to include a large notch, or are converted into bipolar cores at some point in their use-life (Goldstein 2014). Another example is the manufacture of burins on scrapers or blade segments. Maintaining technological strategies that are both flexible and versatile provide a wider range of tool-use options and keep tool-kits simple and portable (M. Nelson 1991).

Large and thick Elmenteitan blades served often as a more portable core form. Thicker blades and segmented blades of the Elmenteitan, and tools made from those blades, were used as

cores for small bladelets or transformed into dihedral burins. In general, increased thickness provides more “stored raw material” in a tool or segment, permitting a wider range of tool transforms, and a longer sequence of tool transforms before becoming expended (see similar discussion of thickness in bifaces in Kelly [1988]). This strategy means fewer blades can be produced from the formal blade cores, but further expands the utility and flexibility of the individual blades.

In essence, the increased investment in formal core design allows for more opportunistic use of generalized blanks. M. Nelson (1991: 65) refers to this as “planned expediency”. In contrast with more general forms of expediency where time, place, and tasks are predictable (i.e. at long term habitation sites), planned expediency is a strategy employed when people *anticipate* uncertainty. Highly uniform blanks are prepared, and variably employed as needed in response to changing conditions. In addition, maintaining consistent blank morphology may indicate an emphasis on modularity within Elmenteitan technological organization. In so doing, people would have more tool options without needing a larger toolkit, which would be advantageous for mobile groups, and particularly for individuals on herding treks who cannot predict what kinds of tools they may need. Planned expediency of modular toolkits may explain the highly variable macro-fracture patterns on geometrics within PN assemblages (Goldstein and Shaffer 2016).

9.2.4 Mobility, environment, and uncertainty

By using the reconstructions of Elmenteitan core design and reduction strategy presented here, along with other studies of artifact form and use-strategies, I have presented a generalized schematic for the Elmenteitan technological strategies. This is the skeleton of a technological organization model, but it is only valuable insofar as it can be fleshed out through assessing

social and economic strategies and environmental conditions in which it functioned. Mobility and environment are the two variables most often invoked to explain patterns in technological organization (e.g. Andrefsky 2009; Binford 1979; Blades 1999; Cowan 1999; Goodale and Andrefsky 2015; Morrow 1997; Surovell 2003). I evaluate the implications of the technological strategies described above for reconstructing mobility, however I follow M. Nelson (1991) in paying special attention to the role of uncertainty in shaping lithic strategies on multiple scales.

Bower (1991) and Robertshaw (1988) have proposed that the Elmenteitan may represent a more sedentary form of pastoralism that may have involved significant plant cultivation, however archaeobotanical evidence for this is lacking. In such a scenario, Elmenteitan groups may have had mobility strategies similar to those of the recent Maasai, wherein a homestead could be maintained and intermittently occupied for up to ten years (Western and Dunne 1979). The technological expectations for such a pattern would be quite different from what has been described above. Cultivation or agriculture are inherently predictable activities that require a set of specialized tools- typically sickles, hoes, and adzes. Only a small number of pecked and ground axes have ever been recovered from PN contexts, and even fewer in specifically Elmenteitan sites. Without the presence of a specialized and/or curated toolkit similar to what is known for other small-scale cultivators globally (i.e. the Near-East [Willcox 2013], the Andes [Capriles 2011], Mesoamerica [Aceituno and Loaiza 2014], East Asia [Liu et al. 2016], or North America [Hammerstedt and Hughes 2015]), it is difficult to find evidence for more sedentary cultivation-based strategies within Elmenteitan technological signatures.

This package of reliability, flexibility, versatility, and planned expediency is typically associated with high residential mobility. More precisely, these technological signatures manifest when people expect to encounter a diverse or unpredictable range of situations (Bamforth 1986;

Li et al. 2016; McCall 2012; M. Nelson 1991; Parry and Kelly 1987). If the toolkit has few items, some of these must be either flexible or versatile in order to meet the variable contingencies of moving from place to place (Kelly 1988; Lee 1979; Shott 1986). This is typically seen as a symptom of high mobility between ecological zones, however this is not necessarily the case for the Elmenteitan. In eastern Africa, resources are unevenly distributed through space and time, such that even a sedentary community experiences a high degree of uncertainty year-to-year. Moreover, major droughts, raids, or livestock epidemics are inevitable, but unpredictable, threats to pastoralist lifeways (Dahl and Hjort 1973; McCabe 1994). Temporal, rather than spatial, variation may impose the same unpredictability that encourages planned expediency among mobile foragers. It is unfortunately difficult to distinguish between the two, and the results of my analyses cannot definitively assign a level of mobility to Elmenteitan groups.

In fact, thinking in terms of a “high” or “low” mobility strategies may be a flawed way to approach this question altogether. Ultimately, the Elmenteitan technological strategies reflect flexibility-as-risk-reduction, not investment in any one strategy. I propose that in this case, mobility strategies operate parallel to technological strategies in remaining flexible and adaptable. Elmenteitan groups may have adjusted mobility strategies in response to the complex and dynamic cycles of climate change in southern Kenya from 3000 - 1400 BP (Ambrose and Sikes 1991; Chritz et al. 2015; De Cort et al. 2013) and shifting internal and external social and political relationships (Lane 2004; Marshall et al. 2011). Individual assemblages reflect snapshots in time of a single, or very few, Elmenteitan group’s mobility, which varied on yearly, decadal, and centennial scales. The record will be biased toward larger and more visible sites, tempting interpretations of increased sedentism. Such a pattern is belied by the lithic technological patterns that show

Elmenteitan strategies continued to reflect preparation for the unpredictable, rather than intensification, through the Pastoral Neolithic.

Inter-site comparisons presented in Chapter 8 may support this hypothesis of variation in mobility strategies. Within the overall homogeneity of Elmenteitan blade morphologies, there is often deviation in one or more variables at an individual site. If variation appeared to pattern regionally it could be evidence for altered mobility strategies to cope with particular ecological constraints and opportunities, and if variation followed a clear temporal trend it could support the Bower (1991) model of increasing sedentism through time, although current data fail to support this idea. There are, admittedly, major gaps in the data, and future analyses could demonstrate that there is diachronic or regional patterning. For the moment, variation appears site specific, rather than environmentally specific. I attribute much this variation to differences in access to obsidian distribution networks through space and time, but some variables are relevant to discussions of mobility. Variation in blade curvature or blade cross-sectional area at some sites may, for example, reflect slight alterations to the Elmenteitan technological strategy to meet specific conditions in place and time.

Intentional manipulation of blade morphologies may also be shaped by the need to provision individuals or groups engaged in logistical mobility. Herding circuits, separate from residential or community-level relocations, are a central component of pastoralist lifeways in eastern Africa, though less discussed in archaeological contexts. Herders or traveling individuals may elect not to take entire cores, but rather to bring pre-manufactured Elmenteitan segments. As discussed above, these are highly versatile blanks that can be manufactured into bladelet cores, burins, retouched tools, or utilized without retouch (see Appendix VI-A). Thicker segments offer

more opportunities for transformations between these options, meaning that individuals can respond to a wide variety of technological needs with only a few obsidian blade segments.

Thickness of segments is simply a reflection of blade thickness, and thicker blades come at the cost of reduced core utility (i.e. fewer thick blades can be produced from a core). Herders in different environments, or facing different rainfall conditions, may have planned for different degrees and intensities of logistical herding or other forms of mobility. Given the fairly predictable relationship between platform thickness and blade thickness discussed above (see also Appendix III-E), people could very easily adjust platform sizes to create thinner or thicker flakes to accommodate the needs of shepherds or other travelers. Variation in blade morphometrics and production strategies between sites includes this dimension of planning. Technological signatures at sites should be discussed in terms of how they relate to general Elmenteitan trends and to local environmental conditions in order to tease apart the complex variables acting on blade manufacture.

The small sample of blades from limited excavations at Remnant produced an interesting assemblage that deviates from other Elmenteitan sites in several ways. Sampling bias may play a role in shaping these patterns, but would not explain why so many metrics and attributes differ at this site. It is only possible to speculate on the factors affecting the Remnant site assemblage presently, and the high altitude moorland location of the site is a tempting place to start.

The ethno-historic record features numerous examples of pastoralists under extreme hardship adopting hunter-gathering lifeways, and moving into highland environments (Mutundu 1998). Economic adjustments like an increase in wild game hunting, a diversified wild plant foraging strategy, or a changes in residential mobility correlating with episodes of stress might

manifest as the kinds of smaller, but statistically significant, deviations in single variables visible that are being picked up in the comparative analysis.

That the Remnant site appears to have had access to only smaller cores, with lower rates of reduction intensity despite proximity to the obsidian quarry might support the interpretation that their access to Elmenteitan exchange networks, or their relationships with stock-associates and trade partners, had become strained. Ceramic evidence do not necessarily support this hypothesis, and soil acidity prevented the recovery of animal bones that might help test it. Even if Remnant does not represent an episode of herders-under-stress, it might be true for some pastoralist sites through the nearly 2000 years of the Elmenteitan, and that could be detectable archaeologically. What is important, is that these adjustments are at the community level, and do not persist in the technological signatures of later Elmenteitan occurrences. Variation is part of the overall strategy of adaptability.

Using the results of archaeological examination of material from the Elmenteitan Obsidian Quarry, the comparative analysis reported here, and the technological descriptions of Ambrose (1980, 1982, 2001, 2002) and C. Nelson (1980), I present a schematic for the Elmenteitan OperationalSequence in Figure 9.1. This is meant only to model general blade strategies, not each possible trajectory. In particular, I present only a few uses of blade segments and as discussed previously, these served a variety of functions in Elmenteitan assemblages.

9.3 Is the “Elmenteitan” a technology or an identity?

The Elmenteitan has been presented as a lithic technological strategy maintained by participation in regional social institutions enduring for almost 2000 years in southern Kenya. These patterns also co-occur with a specific ceramic style and technology, regional distribution, and different mortuary customs (Ambrose 2001). Taken as a whole, the idea of an Elmenteitan identity had a very real emic reality. But identities are complex and can be formed in a variety of ways. Current models for Elmenteitan identity are best informed by the proposal by Ambrose (1982) that the Elmenteitan identity emerged as southern Nilo-Saharan speaking groups dispersed into southern Kenya after c. 3000 BP. This is one of the few attempts to connect archaeological datasets with broader cultural transformations across eastern Africa, and I use the datasets developed in this dissertation to expand on these ideas.

I argue that regardless of the population’s linguistic or demographic history, the social and economic adaptations that Elmenteitan groups developed in southwestern Kenya were substantial, and constitute the manifestation of a new cultural identity. The economic and mobility strategies that conditioned peoples lifeways were responses developed for local environmental conditions in this region. Technological signatures of the Elmenteitan are not known elsewhere, and there is no evidence showing it spread into southern Kenya from the north or west. It is likely that the technological organization defined here developed rapidly by pastoralist populations adapting to regionally specific risks and conditions. Adding further complexity, the technological strategies of a new group would be conditioned by the relationships that developed between herder and hunter-gatherer societies already living around important resources and raw material sources.

Diagnostic features of the Elmenteitan “culture”, including use of Mt. Eburru obsidian, distinct settlement strategies, and use of mica temper, embed the Elmenteitan identity within the

physical landscape of southern Kenya. Possessing obsidian from the Eburru source, making specific types of pottery, or making long flat blades could easily become important identity markers, even if these traits had adaptive origins (Morrow 1987; Hodder 1982). With so many of the “Elmenteitan” cultural and technological traits being tied to, or originating within, southern Kenya, it stands to reason that the Elmenteitan, as an identity, also formed in southern Kenya. Even if the Elmenteitan populations largely originated from migration(s) of a single ethno-linguistic group, what they created was something inherently new.

What we cannot see is whether migrating pastoralists incorporated local hunter-gatherers. If they did, on what scale? Was there long term exogamy or sudden episodes of forced acculturation? Did Elmenteitan groups intermarry with SPN groups? If the ethno-historic record is any indication, there was likely a combination of all of these processes over the 2,000 years of the PN. Gifford-Gonzalez (1998) argued that we should expect significant rates of inter-marriage in the past as migrant herders sought to ensure enhanced security and risk minimization. After so many generations of inter-marriage, absorptions, and movement into and out of pastoralism, is it still accurate to apply any single ethno-linguistic label? Identities underlying the “Elmenteitan” were probably fluid to some degree. They could have changed through time and varied across space. They were probably conceived of differently by individuals of different age, gender, status, and descent group (see Gifford-Gonzalez 1998b; Klumpp and Kratz 1993; Weedman 2002). I argue that at best, the focus on genetic origins obscures the complex population histories and social, economic, and cultural transformations of early herders adapting to the patchy and unpredictable environments of eastern Africa. Instead, we should consider these culture-groups as sets of emergent identities and communities of practice.

Figure 9.1. Proposed Elmenteitan lithic operational sequence.

It is not likely that an Eburran V hunter-gatherer would be able to tell the hue of obsidian tools or mica inclusion in pots from a long distance, making them poor candidates for cross-cultural identity markers (Gero 1989). Only in close inter-personal interactions within a community would “Elmenteitanness” be observable. It may have been more important for Elmenteitan groups to demonstrate their participation in their shared identity to one another than it was for lithics to be identifiable as “Elmenteitan” to SPN or foraging communities. This is to say that access to obsidian from the Elmenteitan Obsidian Quarry could have become an issue of *morality* (sensu Lamont 1992), by which you would be judged by other Elmenteitan communities. To facilitate this identity, Elmenteitan exchange networks distributed obsidian to sites over 250 km from the quarry.

Maintaining this access required the formation of new social institutions and forms of alliance building and maintenance, and those webs of relations were invoked to lend livestock, ensure mutual defense, and long-term economic resilience of participating communities. Access to obsidian from Mt. Eburru became a moral embodiment because it symbolized participation in, and access to, that system of risk-reduction and security.

Many other, and likely more important, means of displaying identity – clothing, beadwork, scarification, hairstyles, ochre use, language – are archaeologically invisible, limiting our ability to accurately reconstruct which aspects of social identity were isochrestic vs. emblematic to Elmenteitan peoples themselves. Lithic remains, which are often the best preserved form of archaeological evidence, also have the potential to contribute to discussions of identity. Wiessner (1983) observed that, among the Kalahari San, small projectile points styles were constrained by raw material availability, and would not become recognized as signs of identity until they encountered much larger projectile points from a previously unknown group. If Elmenteitan, SPN, Eburran V, and Kansyore groups shared parts of the landscape, they are likely to have recognized

that any lithic attributes or styles that reflected internal cohesion also served as an external marker of identity. How identity and technology intermeshed in the Pastoral Neolithic remains speculative, but potentially quite important in understanding the existing data.

Identities are, of course, complex and multi-dimensional. Frachetti (2012) describes pastoralist identities in Central Asia as being the sum of several “packets” – including political structure, ideology, trade, and economy. Different kinds of interactions between groups result in varying alignment of these packets between communities sharing a landscape, presenting the possibility of complex non-uniform cultural systems to develop. Importantly, each group had agency in which “packets” they adopt at any one time. Within this light, it becomes interesting to think about what motivated so many groups to “buy in” to not one, but several, material and economic traditions of the “Elmenteitan”, and what maintained this pattern through the Pastoral Neolithic periods. Participation within ideological and political systems is harder to see archaeologically, and it is possible not all groups were engaged in the Elmenteitan mortuary traditions visible at sites such as Njoro River Cave.

Systemic involvement in obsidian exchange relationships suggests there ideological, as well as material, connections that bound Elmenteitan communities together into a shared identity. The alignment of so many traits within the Elmenteitan is not contrary to models of non-uniform complexity (Frachetti 2012), and viewed within the scope of Elmenteitan-SPN-Eburran V interactions, the Kenyan PN is actually an excellent example of non-uniform interactions among populations producing a kind of institutional “complexity”. Understanding what the Elmenteitan truly represents about peoples strategic choices about their identities requires further investigation of (1) how and when communities diverged from otherwise typical Elmenteitan political,

economic, ideological, or trade-based practices, and (2) what otherwise incentivized the long-term adherence to Elmenteitan traditions visible in the current archaeological record.

9.4 Summary

In this chapter I have developed one of the first comprehensive discussions of lithic technological organization for an early pastoralist industry in East Africa. Developing an interpretive framework that applies technological organization principles to mobile herding lifeways, as opposed to hunter-gatherer lifeways, presented challenges. Identifying the lithic attributes and metrics that best capture inter-assemblage variability is an important first step, and I have reviewed the advantages and disadvantages of different measures and measurement techniques for future studies that will expand upon this work.

Adapting concepts of lithic toolkit reliability, flexibility, and versatility (after M. Nelson 1991) to the case study of the Elmenteitan contributes a much-needed vocabulary for discussing and interpreting variation within, and among, Pastoral Neolithic and hunter-gatherer culture-groups. Interpretations need only to consider the particular environmental, economic, and social constraints of the economies under study. For ancient pastoralists, these include mobility strategies oriented around the need to bring herds to pasture, the need to cope with environmental uncertainty, and management of relations and interactions with other pastoralist and hunter-gatherer groups. The Elmenteitan case study presents only one set of responses to these needs and conditions. Evaluating how raw material use, core reduction, and tool use demonstrate different emphases in terms of reliability, flexibility, versatility etc., provides a means to directly compare the strategies of the many different cultural entities co-existing across eastern Africa during the Pastoral Neolithic. The advantage of the technological organization approach is that it permits

these comparisons regardless of different raw material choices, and is not impeded by the similarities in tool-form that have been problematic for previous studies (e.g. Mehlman 1989; Nelson 1973). This study has demonstrated the great potential of these research themes for reconstructing mobility strategies, economic structures, and for re-vitalizing lithic analyses in the context of early East African herders.

This study has also challenged the general framework of lithic technological organization by stressing the importance of social and cultural practices, learning, and gendered production, in shaping lithic signatures. The realities that cultural choice over raw material selection, apprenticeship, and the division of tasks between people of different ages and genders affect the material record requires they be integrated into our interpretations. I argue this door swings both ways, and lithic technological organization itself is a dimension of culture. Technology intersects with conceptualizations of identity, ethnicity, and language (e.g. Ambrose 1982), and should continue to play an important role in interpreting the social mosaic that is a hallmark of Holocene East Africa.

Chapter 10

ACTIVITIES AND LITHIC TECHNOLOGY AT THE ELMENTEITAN OBSIDIAN QUARRY (GsJj50): IMPLICATIONS FOR ELMENTEITAN SOCIO-ECONOMIC ORGANIZATION.

10.1 Expectations

In the previous chapter I discussed the social, economic, mobility, and environmental dimensions of Elmenteitan technological organization, and stressed evidence for a system of obsidian exchange/distribution that was integral in maintaining those signatures. Now, I will refocus attention back to the Elmenteitan Obsidian Quarry as the source for this exchange system, in order to begin testing models for how it was organized and how it operated. The hypothesis that the quarry could have been under the centralized control of a single group, and may have contributed to nascent inequalities within the Elmenteitan group, serves as an important entry-point for this discussion. I rely on the strong correlation between behavioral patterns at lithic quarries and broader forms of social organization on the landscape to project interpretations for the Elmenteitan Obsidian Quarry onto the broader Elmenteitan social landscape (Andrefsky 1994b; Beck et al. 2002; Messineo and Barros 2015; Shott and Olson 2015; Torrence 1986; Tripcevich and Contreras 2013).

Evidence in support of the Robertshaw (1990) hypothesis for obsidian quarry “control” would include a presence of Elmenteitan habitation sites near the quarry, spatial organization of Elmenteitan extraction and quarrying, and homogeneity in core preparation strategies (after Dillian 2007; Gramly 1984; see also review Chapter 3.8). These lines of evidence are necessary to support the proposal by Robertshaw (1990) for control of the quarry site by particular individuals or

lineages, and the physical presence of local habitation sites is a particularly important cornerstone of that model. It is easier to exert control over a spatially discrete resource than one that is widely available, and in some instances isolated lithic outcrops have fallen under hierarchical control (Arnold 1990; Shafer and Hester 1991; Shaw 1994). Instances of hierarchical control tend to occur when lithic raw material is being used for specialist production of elite goods (e.g. Maya eccentrics), or implements to produce elite goods (e.g. microdrills for bead production). When lithic materials are broadly consumed for utilitarian tool production, isolated lithic sources and quarries are used more cooperatively between or among communities (Ericson 1984; Dillian 2006, 2007; Jackson and Ericson 1994; Horowitz 2015; McCoy et al. 2011).

Diverse behavioral and technological signatures, the existence of multiple quarrying and lithic workshop areas around the obsidian source, and a lack of nearby habitation sites would support an alternative models for more communal and cooperative quarry access by Elmenteitan communities. Regional settlement patterns and the diversity in lithic technological signatures and core designs, and patchy distribution of core preparation areas support the alternative hypothesis of communal use of the Elmenteitan Obsidian Quarry. A strong spatial division of activity areas maintained through nearly 2000 years of site use does fit with expectations for organized control of quarrying, presenting some interesting complications for interpreting how Elmenteitan herders accessed and used this site. In this case, it becomes necessary to explore alternative configurations of resource access and management that do not involve hierarchies, ownership, or control using archaeological and ethno-historic examples from inside, and outside, of Africa.

I address and evaluate each category of evidence relative to these expectations for the Elmenteitan Obsidian Quarry on Mt. Eburru in the sections below.

10.2 The Organization of Activities at the Elmenteitan Obsidian Quarry

In this section I present a reconstruction of the full operational sequence involved in Elmenteitan use at the Elmenteitan Obsidian Quarry, highlighting technological lines of evidence relevant for further evaluating the hypothesis for a single community managing quarrying activities. Organization of these activities is a product of the social institutions involved in obsidian access, and by relation the broader set of social relations and systems structuring the distribution of obsidian across the Elmenteitan landscape.

10.2.1 Site access

Lacking evidence to support exploitation by locally residing Elmenteitan groups, quarrying parties would likely have had to travel to the quarry site from other locations in southern Kenya. Given that the highest density of reported Elmenteitan habitations is in the southwestern highlands regions, it is reasonable to assume that groups may have been traveling at least 20-50 km. This may change in the future with expanded research and survey, which may refute the hypotheses presented here and require re-evaluation of the role of the Elmenteitan Obsidian Quarry.

Groups on logistical quarrying trips could have traveled along three general and non-exclusive paths; (1) directly over and across the forests and altitudinal gradients of the Mau Escarpment (2) around the southern edge of the Mau Escarpment following grasslands northward past Lake Naivasha up the southern or eastern flanks of Mt. Eburru, or (3) over or around the northern Mau Escarpment forests and up the northern flanks of Mt. Eburru. The first route may have been tenable during dryer periods of the Late Holocene when the ecology was more open and less densely forested. Sites like Remnant demonstrate that Elmenteitian herders maintained a presence along this straight-line route over the Mau. The second route moving around the southern

Mau Escarpment is the least-cost-path (Goldstein 2014), but is longer and would involve traveling past, or directly through, SPN quarry sites around Oserian and Sonanchi Crater, west of Lake Naivasha. Rockshelter occupations like Enkapune ya Muto and Enkapune ya Sauli could have supported logistical travel along the flanks of the Central Rift (not much out of line with model 1). The possibility of a northern route is the least likely based on distance, although several sites to the north of Eburru including Njoro, Keringet, and Elburgon indicate it may have been used.

10.2.2 Initial quarrying

Quarrying itself began by extracting large obsidian nodules from the largely linear band of accessible surface exposures across what is defined as Area 2. There is evidence of extraction along the entire extent of the obsidian exposures, but the densest deposits of quarrying debris are near the easternmost edge approaching the modern road cut. I found no evidence for quarry pits, although more expansive testing may demonstrate greater diversity in quarrying methods.

Prehistoric knappers then attempted to extract nodules of relatively pure glass through the removal of external cortex and internal heterogeneities. Given the high frequencies of flaws and inclusions evident in the debitage of Area 2, this processing was likely the most labor intensive component of core preparation. Preservation of intact conchoidal cones suggests an initial “testing” or “opening” of cobbles with oblique hard hammer strikes. “Prepared” nodules ready for blade production rarely exceed 15-20 cm in maximum release surface length. This likely reflects an intentional selection of cobbles, however given the rate of inclusions it might simply have been difficult to find larger nodules of pure glass. In some cases, it is apparent that the knapper abandoned large cores after initial removals revealed a substantial internal flaw.

The *chaîne opératoire* then diverges in two directions. Fragments of varying sizes with significant flaws were reduced along existing edges with little apparent attention to design or shape. These could be either flake or bladelet cores. In some cases it is clear that small obsidian fragments were selected for ad-hoc bladelet production. Given the expedient selection process, it is sometimes hard to determine how intensively the cores were reduced. The low number of flake removals (Figure 7.1) suggests that cores were often very opportunistic with short use-lives. One type of opaque banded green obsidian was reduced extensively in Area 2, but is not present either in Area 1 or at any Elmenteitan assemblages so far excavated in Kenya. Expedient cores were abandoned in-place within the thick layer of quarrying and early stage reduction debris within Area 2. There are very few tools and no bone, ceramic, or charcoal from Area 2, supporting the interpretation that this area was consistently used for quarrying and nodule testing.

10.2.3 Operational sequence

High-quality obsidian nodules were brought to discrete loci in Area 1 for initial shaping and blade reduction, and lower-quality nodules were reduced and abandoned within Area 2. Large cores recovered on the surface and in the archaeological horizon across Area 1 often have large flaws revealed in the most recent blade removals and were abandoned as a result. From this point the reduction sequence diverges again. Roughly 40% of the cores were used for expedient flake reduction, and the blade cores exhibit a wide range of morphologies. Some of these morphologies, like bi-directional/opposed or multi-platform orientations and low length-to-thickness ratios are rare in Elmenteitan blade assemblages (except at the Remnant site) and are generally more characteristic of SPN blade technology.

Even though there is considerable diversity in blade core morphologies and reduction strategies at the quarry, the most common type of core being reduced is the single platform “faced” type. This may be the most “formalized” design present at the quarry. Preparation for producing these cores began with an intensive effort to remove flaws and hinge or step fractures remaining from early stage nodule reduction. This is followed by the first efforts to impose a shape by creating a striking platform. Variation in flake scar directionality and the high rate of platform removals during early stages appears to indicate that there was no single or consistent approach to core preparation, even when the end-goal was producing the typical single-face core type. Similar diversity in core preparation has also been documented in cases of lithic production for non-centralized exchange in Hawai’i (Cleghorn 1986), North America (Root 1997), and Indonesia (Stout 2002).

Once platforms were prepared, an initial phase of blade removal helped to shape the core. Based on blade lengths, blade reduction sequences are established by core lengths of 15-12 cm. This is the range of maximum length of blades at Elmenteitan sites sampled in the comparative analysis, and likely represents the size at which cores are exported. Cores were being prepared fairly intensively, suggesting efforts to reduce transport costs for longer distance return trips (after Ericson 1984; Torrence 1984). It is impossible to know what ratio of quarried obsidian was transported offsite, however the density of debitage suggests possibly hundreds of cores were intensively reduced at the quarry. Most of the blade reduction is within the size range of 10-2 cm, which is nearly identical to the range of reduction observed at Elmenteitan habitation sites (see Chapter 8). This does not reflect a standard quarry scenario where we would expect early stage debris to dominate the assemblage, as end phases of reduction would take place at habitation sites. One possibility is that this more “curated” pattern may be related to the high occurrence of internal flaws and heterogeneities in the nodules people were selecting (see Binford 1979; Bamforth 1990).

Another possibility is that people took advantage of the raw material abundance at the quarry to practice or engage in learning.

Several technological dimensions reflect overall consistency in blade reduction strategy and the desired blade morphology. The typical Elmenteitan blade here is straight, has a very low curvature score, and a parallel flaking pattern with 2-4 remnant flake scars. These traits begin to be systematically implemented beginning at release surface lengths of between 7 and 8 cm. Based on the excavated assemblage, there is also a consistent pattern of shifting design evident in flake scar count, cortical rates, platform rejuvenations, and qualitative assessments of core shape beginning when cores reach lengths of 5 cm. It appears that cores reaching this length are rotated so that an adjacent side of the core can be exploited for blade reduction. Error rates also spike around this length, and so may be related to this re-orientation of core shape. At some later point, cores of various shapes converge on either a bipolar or pyramidal bladelet morphology. These types compose the majority of small, late-stage, cores.

10.2.4 Organization of core production

As best as can be reconstructed, the data on core morphology and reduction sequence present slightly conflicting perspectives. Wide variation in core shape and design indicates a less systematic approach to core preparation than would be expected from a single community managing core preparation. This is more consistent with diverse Elmenteitan groups accessing the quarry and producing cores according to specific regional strategies or styles (after Ericson 1984). Within this variability however, the trajectory for single platform parallel orientation cores appears far more consistent than for other core forms present in the assemblage, and standardization of the operational sequence is an expectation for a single group mass-producing cores for exchange

(Arnold 1990; Root 1997). Furthermore, the discrete spatial patterns of separate extraction and early stage reduction area of Area 2 versus the “living spaces” or “camp areas” of Area 1 at the Elmenteitan Obsidian Quarry where more intensive preparation and reduction took place, implies organization. This organization was maintained through time, reflecting a consistent set of rules for behavior at the quarry.

Other spatial and technological signatures conflict with this interpretation, however. A major obstacle in supporting this model of more centralized control, and thus supporting the hypothesis for hierarchical management of core preparation, is the abundant evidence for intensive blade reduction of formal blade cores well beyond the point at which they could be transported or exchanged. Unless people were principally transporting large numbers of blades rather than cores, intensive reduction behavior cannot reflect centralized or controlled lithic production. If anything, this pattern is more indicative of learning and practice (Milne 2005; Stout 2002; Weedman 2002; Will 2000). Rules over the spatial organization of quarrying might have been enforced within the social institutions involved in sustained knowledge transmission.

Contextualizing the apparent uniformity of the single platform blade core sequence within regional patterns sheds important light on these alternative interpretations. As revealed by the comparative analysis in the previous chapter, the single platform/reduction face core type and its corresponding operation sequence dominate all Elmenteitan assemblages from across southwestern Kenya. It is not a quarry-specific strategy, but is an underlying technological strategy defining the assemblage group. Without regional variation, we can neither assume that variation at the quarry reflects the presense of different sub-groups, nor use uniformity as a sign of a single social group controlling quarry access. Following Binford (1979), expedient and informal cores were likely used as an ad-hoc strategy in a context of raw material abundance, and so this diversity

is not necessarily spatially meaningful. The abundance of expedient cores does, however, imply a kind of informality to quarry activities that is not in line with specialized production for exchange. More analysis revealed site-to-site variation in individual technological signatures, like platform preparation and size, blade morphometrics, and curvature that do not track with distance from the quarry or overall blade length.

There are not enough sites from any one environment or ecology to determine what is driving these differences. If a single Elmenteitan community was consistently using the quarry, it might produce a somewhat unique signature reflective of the documented variation in specific attributes at specific sites. Instead, the quarry assemblage exhibits the entire range of variation demonstrated across all other Elmenteitan samples. As demonstrated by the synchronic chronology of the dated deposits, this variability cannot be easily attributed to time averaging. I interpret this to be evidence for considerable plurality of either “style” or skill amongst knappers at the quarry. In either case, it is not likely that the quarry was occupied by a single group managing quarrying and core production to supply regional exchange.

Evidence from the quarrying strategies, lithic operational sequences, and core design falls on the side of cooperative access and use of the Elmenteitan Obsidian Quarry by multiple communities. However, it is by no means overwhelming and does not preclude some organization in quarrying. The implications of the maintained spatial boundaries between activity areas and of uniformity in core production strategies must be seriously considered.

10.3 Spatial correlates for site access and use

10.3.1 Regional and local perspectives

Regional and local settlement patterns are among the most important lines of evidence in examining the possibility that quarry sites were controlled by particular communities or individuals (Dillian 2007; Gramly 1984; Horowitz 2015). Archaeological survey and mapping around Mt. Eburru suggest that prehistoric herders traveled to the Elmenteitan Obsidian Quarry on Mt. Eburru logistically (*sensu* Binford 1979), and evidence fails to support the model of obsidian control within Elmenteitan quarry use.

Geography and ecology of Mt. Eburru provide some preliminary, though circumstantial, evidence against the possibility that people maintained residence near the quarry site. One factor affecting the likelihood of permanent settlement on Mt. Eburru is the lack of perennial sources of potable water on the upper slopes of the mountain. There are larger drainages along the southern portions of the mountain and ephemeral streams within the high-altitude forests, but these are not dependable and would not support a long-term human population with herds.

Highland tropical forests, like those on the upper slopes of Mt. Eburru, are not easy places in which to keep cattle or small stock, due the increased risk of livestock infections like hoof-rot, and cold stress on the animals. Forests are typically avoided by contemporary pastoralists with herds, but may be used as refuges or visited in order to trade with forest specialized hunter-gatherers like the Okiek (Blackburn 1982; Mutundu 1998). Elmenteitan sites like Remnant and Enkapune ya Sauli are unusual in their high altitude locations, however these sites might have been in more open ecologies when they were occupied during the Pastoral Neolithic (see discussion in Ambrose 1984c). Archaeological surveys around the quarry site and in targeted areas across the eastern flanks of the mountain also failed to locate additional sites. Excavations revealed the

presence of ceramics and fauna within quarrying deposits in Area 1 of the Elmenteitan Obsidian Quarry on Mt. Eburru, but these are quite dissimilar from known open-air residential assemblages and too low in frequency to indicate a significant habitation (see Robertshaw 1990, 1991).

If Elmenteitan communities had maintained residential sites anywhere in the area throughout some or all of the Pastoral Neolithic, archaeological surveys should have detected at least some of these sites. The high rates of andisol soil development along with colluvial deposition along the slopes of the mountain could have contributed to obscuring the presence of some archaeological sites, but not all of them. Beyond the 40,000 sq. m. area surrounding the Elmenteitan Obsidian Quarry that we were able to survey more intensively, the informal surface and road-cut surveys also failed to locate any new sites with the exception of a small scatter of material eroding from a large grassy area approximately 4 km east and 350 m downslope of the quarry site. This appeared too small (< 20 sq. m) and too low-density to account for a substantial habitation, but does speak to more ephemeral use of the mid-slopes in prehistory.

There are some small Pastoral Neolithic sites on the lower slopes of mountain (Ambrose pers. comm.) however the next nearest documented Elmenteitan occurrence is the Eburu Station Lava Tube site, 7 km to the north of the quarry site. Taking an even broader perspective, many Elmenteitan sites within a 25 km radius of the obsidian quarry are rockshelter occurrences that are unlikely to have supported typical residential occupations⁵. Ethnohistoric herders in Kenya use rockshelter sites for short-term penning on grazing forrays (Shahack-Gross et al. 2003), or in the event of crisis (Mutundu 1998). Herders do not typically maintain long-term residences in caves (Mbae 1990).

⁵ Parts of Ndabibi west of Lake Naivasha have evidence for several open-air Elmenteitan sites, however these have not yet been described or published.

The strongest evidence in support of a hierarchical, centralized control, model of quarrying on Mt. Eburru is that surveys failed to locate additional spatially discrete quarrying areas. Elmenteitan quarrying activities surprisingly concentrated within a 200-400 m extent for c. 2000 years. Mapping efforts may indicate that the limited extent of the obsidian flow exposure may be one practical reason for this pattern that does not involve hierarchical control. There are separate, geochemically similar, obsidian exposures around Mt. Eburru at the Eburru Road, Cedar Hill, and Ilkek sources, but these do not have identifiable quarries and indeed do not appear to have been sources for prehistoric tool production (Brown et al. 2013). If Elmenteitan communities were intent on quarrying on the upper slopes of Eburru, they would have had little choice but to use the GsJj50 quarry site where large nodules are available near the surface. Quarrying such deposits could have been undertaken casually, without the kinds of intensive mining efforts that might require centralized organization (Shaw 1994).

Taken together, the evidence does not support a model where Elmenteitan communities maintained a consistent presence near the quarry, on Mt. Eburru broadly, or even in the surrounding portions of the Central Rift Valley. This would make centralized control of the site by a particular community or lineage unlikely, but not impossible. Although the evidence refutes a cornerstone assumption of the Robertshaw (1990) hypothesis, it is important to consider and evaluate alternative ethnohistorically documented forms of resource control.

10.4 Archaeological and behavioral patterns in Area 1

10.4.1 Artifactual and faunal evidence

Archaeological signatures present in Area 1 conflict with assumptions that quarry deposits should be comprised of undifferentiated lithic debris. While this is true for Area 2, excavations in

the Area 1 present a more complex narrative of activities taking place at the Elmenteitan Obsidian Quarry. The presence of ceramics and fauna in these areas imply people were processing and consuming food at, or near, the quarry. It is also only in these patches that there is evidence for opportunistic lithic tool use, repair, and retooling. From the comfort of these “camps”, Elmenteitan producers prepared cores bound for transport down the mountain and across the landscape. It is clear from the abundant evidence of small blades and bladelet cores that people were also engaged in intensive reduction, well beyond initial core preparation.

A limited range of tool types, coupled with a low variability in expedient utilized pieces is a pattern associated with short-term occupations at sites used for specific tasks (Binford 1979; McCall 2012, see also Morales *et al.* 2015). The degree to which people invest in informal tools is often correlated with group mobility, in the sense that the longer people occupy a single location, the more likely they are to produce “informal” tools for expedient tasks (Andrefsky 2010; C. Nelson 1991; Shott 1986). The small sample of utilized pieces in the collection implies they were infrequently produced, consistent with expectations for short term occupations. Relative rates of bipolar core production are also loosely associated with duration of site use (Parry and Kelly 1987; Wallace and Shea 2006), and this pattern was demonstrated by Robertshaw (1990) for the Elmenteitan. Low frequencies of splintered pieces and other bipolar elements in this collection supports short-term habitations.

Ceramic and faunal evidence also supports use of short term camp sites at the Elmenteitan Obsidian Quarry. Ceramic vessels are unlikely to be manufactured at a specialized quarry site with no reliable sources of either water or clay. It is more probable that people traveling to the quarry brought vessels with them, although future petrographic and geochemical analysis is required to

determine where vessels originated. The nearest source for mica is in the Lemek Hills, around 70 km away. Either the ceramics, or the temper, were moving at least that far.

Variation in mica temper, sherd thickness, and coloration may indicate that the vessels were produced by several different Elmenteitan communities living in different areas, all of whom had access to the site. Only large bovids are identifiable from the excavated material, again setting these remains apart from those typical pastoralist habitation sites where small stock is more common (Marshall 1990, 1991; Simons 2004; Robertshaw 1991). Preferential consumption of cattle is suggested by several researchers to be associated with more ceremonial forms of eating among pastoralist communities, particularly the meat-feasts of warrior groups (Gramly 1975; Gifford et al. 1980: 87; Mbae 1990: 286). Further excavations and analyses, especially in terms of ceramic sourcing and residue studies, are essential for testing these hypotheses.

10.4.2 Implications of the chronology

The narrow date range for the quarry sample hints at an interesting pattern of site use that is not usually observed at prehistoric lithic quarry sites. These dates seem to suggest rapid but intensive deposition in a single area. I suggest two possible scenarios that could explain this pattern. First, behaviors surrounding quarry exploitation could have changed through time. In such a scenario, Elmenteitan herders may have begun transporting raw or minimally processed nodules directly, shifting to more intensive processing as evident in Area 1 around 2,160 cal. BP. Removal of whole cobbles with little or no preparation by earlier and later quarrying groups is possible, but this is not supported by existing data.

Alternatively, quarrying strategies may have been consistent through time, but with spatial variability in the placement of reduction activities, resulting in the observed archaeological lenses

at the Elmenteitan Obsidian Quarry. A shifting pattern for workshopping would not be wholly unexpected. Activities at the “camps” would produce dense accumulations of volcanic glass debris, dissuading later parties from re-using the exact same location for their own core preparation and eating. In this manner, activity areas may have drifted around the obsidian exposures through the Elmenteitan sequence. Overall, I support this scenario of shifting activity patterns as being the most likely. The slightly later radiocarbon date to the south of the others may be seen as tentative support for activities shifting in that direction. Some temporal variability in quarrying strategies is possible; however the overall cultural continuity apparent in many aspects of the Elmenteitan casts doubt on the likelihood of rapid shifts in behaviors at this site.

10.4.3 Interpretations

The patterns evident from spatial analysis, technological analysis and other artefactual patterns build a case for communal, rather than controlled, quarry access. Lithic, ceramic, and faunal patterns from the Elmenteitan Obsidian Quarry all suggest a special purpose site where a narrow range of activities were being carried out. Spatially and temporally discrete activity areas suggest that these quarrying activities occurred in relatively short episodes. Detailed analysis of several lines of evidence from the Elmenteitan Obsidian Quarry support a model of individuals or small groups traveling to, and using, the quarry site (Binford 1979; Gould and Saggers 1985; Tripcevich and Mackay 2012). In sum, these lines of evidence indicate a pattern of logistical quarry use by small groups. Highly variable core morphologies at the site also refute the hypothesis of production by a single community for export. Centralized control by a single local community may still be possible, but is not supported by the current evidence.

10.5 Alternative models for Elmenteitan obsidian access

10.5.1 Alternative configurations

First, it is important to recognize that there are different degrees of resource “control” among mobile non-state societies, ranging from formal ownership to informal and negotiated land-rights (Jarman 1972; Zedeno 2008). One common idea in archaeology is that establishing cemeteries in a place can be used to signal resource or land ownership remotely (Chapman 1995; Loring 1985; Renfrew 1986; Saxe 1970). Known Elmenteitan mortuary sites are restricted to the Central Rift Valley, despite habitations concentrated in the southwestern highlands. Burial sites like Gamble’s Cave, Egerton, Marula Rockshelter, and Bromhead’s are situated either along the flanks of Mt. Eburru or closeby, although more substantial Elmenteitan mortuary sites of Njoro River Cave is located 40 km to the north. The resource-control mortuary hypothesis is more recently critiqued as overly simplistic (Brown 1995; Gillespie 2001), and recent work questions its application for mobile herders (Brass 2016). Even so, the close proximity of most of the documented Elmenteitan burial sites to Mt. Eburru may indicate some dimension of territory building within the Central Rift Valley that is not present elsewhere.

Ethnographic perspectives from more mobile groups are also relevant for generating models for alternative forms of resource control that may have existed around the quarry, which can be tested archaeologically. When diverse mobile groups in the Kalahari converge around lakes during dry seasons, land-rights are maintained entirely in the shared social memory of participating communities (Hitchcock and Bartram 1998). In the entirely different environment of the Nunavik Arctic, Inuit populations integrated ownership and occupancy rights directly into place names (Müller-Willie 1989). Historic eastern African pastoralists also used communication networks and social memory to maintain knowledge of land-use rights between groups, and often responded to

violations through armed conflict (Ndagala 1992; Little 1998). It is possible, from this perspective, that a single Elmenteitan community or particular lineages could have maintained some kind of control over the obsidian quarry without maintaining a nearby physical presence.

Identifying clear material correlates for these models is difficult, however there are a few important points to consider. The desire to establish land-rights like those among recent herders and foragers is typically a result of competition over grazing land, fishing locations, or hunting areas. The Elmenteitan Obsidian Quarry is neither the only obsidian source people could have exploited, nor is it in a location where herders would frequently travel in the course of grazing or other economic activities. Surveys failed to identify any additional, clearly separate, obsidian quarrying areas within or around the site that might reflect these kinds of inherited land-rights. It is thus unlikely that resource control mechanisms would have been in place for the quarry-source.

I conclude that the data do not support any likely configuration of control or restriction of access to the Elmenteitan Obsidian Quarry by a single Elmenteitan group. The results of spatial analyses and mapping do not demonstrate nearby Elmenteitan habitations. A permanent presence is an important expectation for maintaining control within a social group. Other models of remote control or ownership through more diffuse social systems are also difficult to support with the limited archaeological resolution available. There is also no evidence that the Elmenteitan groups proactively protected the quarry from use by SPN herders or Eburran Vb hunter-gatherer groups, both of which were occupying the surrounding regions and using quarries in the Naivasha basin, under 15 km away during the period the Elmenteitan Obsidian Quarry was in use. Given that there are such stark spatial divisions in quarry use in the Central Rift Valley, a model of shared-but-separate access to resources in a concentrated area, like that noted for the Kalahari !Kung may be relevant for cross-cultural resource control during the Pastoral Neolithic.

It is important to realize, however, that many alternative forms of resource control would leave little-to-no trace in the archaeological record and absence of evidence is not inherently evidence of absence. Spatial patterning is also only one line of evidence, and there are expectations for how internal site structure, quarrying patterns, and quarry lithic production, could reflect centralized, or at least managed, control.

10.5.2 Access and use of the Elmenteitan Obsidian Quarry

Robertshaw (1990) and Ambrose (2001) have highlighted the importance of considering the socio-economic implications of different patterns for Elmenteitan quarry access and use. The alternative models for access and use of the Elmenteitan Obsidian Quarry developed here through archaeological fieldwork, and artifact and lithic analyses offer new insights on the social and economic organization of the Elmenteitan. This presents an opportunity to develop a renewed consideration for the role of social institutions and structures in shaping the spread of pastoralism in eastern Africa.

This study rejects the hypothesis that a single community controlled the quarry, or by extension the distribution of obsidian within the Elmenteitan cultural sphere in favor of more communal and open quarry access by multiple groups. I hypothesize that individuals or small groups traveled to Mt. Eburru for the specific purpose of quarrying obsidian and preparing blade cores. Travel to the quarry site from the floor of the Central Rift Valley or from destinations further afield would have not have taken more than a few days to a week, but required being provisioned with water or milk in either organic containers, or the ceramic vessels recovered during excavations. If the large bovid remains from the site are cattle bones, either meat or cattle would have to be brought up with the quarrying parties. Lack of evidence for local habitation sites or vertical transhumance within Elmenteitan herds suggests that quarry parties may have had to bring

livestock from some distance. Donkeys may have been assisted in the transportation in food and water up the mountain, and the movement of obsidian cores on the way down.

Quarrying groups may have come from fairly distant communities. An abundance of large and small blade debitage demonstrates that cores were being extensively prepared and reduced at the site. Extensive preparation is generally associated with longer distance transport, rather than local acquisition (Torrence 1984; Weisler 2011). Large blades at Ngamuriak and Olopilokunya suggest that herders living between 70 and 100 km from the quarry had fairly direct, early stage, access to cores (see Robertshaw 1990). Communities in the Lemek-Mara regions may have been able to send representatives or quarrying parties to the obsidian source, or otherwise maintain fairly direct access to obsidian cores. Sites within the quarry ‘catchment’ (Gambles Cave, Bromhead’s site, Suswa Lava Tubes) have very large maximum blade sizes again reflecting direct access, while some sites close to the quarry like Njoro River Cave, Enkapune ya Sauli, and the Remnant site received smaller cores, or had limited access to the quarry or obsidian distribution networks. Different communities seem to have had varied levels of obsidian access at different times. Smaller blade assemblages at the Lake Victoria Elmenteitan sites of Wadh Lang’o (Lane et al. 2007) and Gogo Falls (Robertshaw 1991) indicate constrained access and that people living on the most distant Elmenteitan sites relied more on secondary access through exchange to acquire obsidian.

10.5.2 Proposed social institutions

Access to high quality obsidian for blade production was clearly important for Pastoral Neolithic groups across southwestern Kenya, with specific access to obsidian from Mt. Eburru being especially valued by Elmenteitan groups. Maintaining that access at sites up to 250 km away from the source from c.3000 - 1400 BP required significant social and energy investment. I have

outlined a model of small-party quarrying feeding a complex network of shifting direct access and subsequent exchange. But how formalized were these institutions within broader social structures?

There are many structurally similar contexts of long distance obsidian distribution that may inform Elmenteitan models. In Andean contexts obsidian acquisition and exchange among agro-pastoralists was a seasonal activity, and was associated with important ritual events (Browman 1990; Tripcevich 2010: 64). If obsidian acquisition was embedded within ritual practices, age-grade structures (or comparable social systems), or social alliance building, then participation in quarrying would constitute an important dimension of reifying group identity and reciprocity. Increasing cooperation and organization would make the Elmenteitan manifest as a more cohesive culture group than the SPN. Patterns of direct access similar to those we have proposed are noted for obsidian access at Glass Mountain, California, where experienced hunter-gatherer knappers were sent to acquire raw material regularly based on community needs (Dillian 2002). Less formalized systems where quarrying was undertaken casually based on practical need would imply that while cooperation was still important, it was not a major point of strategic emphasis.

10.5.3 Relational analogies from African ethnography

There are several ethnographically documented material and behavioral patterns among East African pastoralists that provide the ‘cables-and-tacking’ necessary for drawing relational analogies to the archaeological patterns at the Elmenteitan Obsidian Quarry (*sensu* Wylie 1989). Warrior groups among ethnographic herders in eastern Africa, particularly Maa speakers, focus activities on areas far from habitations, preferably inside forests or rock-shelters away from normal pastoralist settlements (Rigby 1979; Gramly 1975b). The upper slopes of Mt. Eburru would perfectly fit these needs, and interestingly all Elmenteitan sites within the surrounding Central Rift

Valley are rock-shelters or other special purpose sites. Thomson's (1887) encounter with warriors undertaking a meat-feast among the steam-vents not far from GsJj50 attest to it being a desirable location for such gatherings amongst recent populations. In fact, this account suggests a powerful spiritual significance to the steam vents on the upper slopes of Mt. Eburru:

“Here our venerable guide caused us to take grass in our hands as we approached the mysterious place. We soon reached the holes, and to propitiate the troubled spirits of the earth we threw our vegetable offerings into a great pit, from which with curious regularity were puffed or hissed out clouds of steam, accompanied sometimes by gurgling, at other times by a rumbling, noise...”

(Thomson 1887: 197)

Evidence for small scale camps in this remote and unusual quarry comes from ceramic, faunal, lithic, and spatial data from excavations at the Elmenteitan Obsidian Quarry. I hypothesize that this evidence may also hint at the existence of similarly-structured social institutions. The specialized nature of the ceramic vessels and shaped tools imply a narrow range of activities. The high rate of expedient tools and disproportionate lack of scrapers and other domestic implements could imply that the individuals at the site were not operating with a “domestic” sphere. Acquisition of obsidian, ochre, medicinal plants, and other resources specific to Mt. Eburru fits well within the tasks of warrior or age-grade type institutions. As highly mobile sub-groups that visit a broad range of disparate communities, young men (assuming the institution was so structured) would be well suited to the task of distributing obsidian.

Friendships and alliances formed through logistical resource access in ethnographic and ethnohistoric contexts often form the basis for sustained trade relationships. Participation in an age-grade establishes social bonds among individuals across the landscape, and these carry important obligations for reciprocity. These relationships are invoked during times of economic hardship, disease, or drought, to help in recover and re-establish herds. The importance of the social institutions under discussion is likewise not restricted to quarrying- but may have served as a mechanism for maintaining long distance alliances. The existence of such a system, possibly involving use of the quarry, would have helped to maintain the strong degree of social integration and stronger corporate structure within this assemblage group noted by Ambrose (1980, 2001). I have presented only one possible analogical structure for how such systems may have operated, and certainly there is a wide range of potential age and gender configurations possible. This is a hypothesis that could eventually be tested through further research on variability among Elmenteitan sites with gendered as well as economic perspectives.

10.6 Learning, practice, and apprenticeship

10.6.1 Communities of Practice

Over time, it is likely that just as with groups travelling to cattle markets today, parties traveling to the quarry would have contained individuals with different degrees of knowledge as to factors such as the location of the site and obsidian exposures, quarrying strategies, rules regarding spatial use of the site, and core preparation sequences. The entire trip and the quarrying and lithic reduction activities carried out would have been learning experiences for younger individuals, who necessarily had to learn these strategies and traditions. Participants in quarrying events therefore formed a “community of practice” (see Lave and Wenger 1991; Wenger 1998) in

which knowledge and skills were passed down from more- to less-experienced knappers. It is through this process that the consistent traits of Elmenteitan lithic technology, as well as important ritual/spiritual and ecological knowledge, may have been reproduced through time.

Places of raw material abundance are ideal locations to look for evidence of the learning and apprenticeship that would identify a community-of-practice component to social institutions involved in lithic quarrying (Finlay 1997; Ferguson 2008; Shelley 1990; Will 2000; Milne 2013: 335). This would be amplified in the case of the Elmenteitan, who relied so heavily on obsidian for tool production. Learners and novices inherently make more mistakes and “waste” raw material at higher rates (Finlay 1997; Pigeot 1990; Shelley 1990; Walthall and Koldehoff 1998; Will 2000). At habitation sites far from the quarry where obsidian access was constrained, families may have been hesitant to turn cores over to novices. Identifying novices in the archaeological record is notoriously problematic, however archaeologists agree that this must be based on identification of errors and mistakes in assemblages (see Chapter 3.6).

10.6.2 Evidence from the quarry site

Quantifying error rates at the Elmenteitan Obsidian Quarry, and comparing these to other sites across the landscape, indicates that learning may have taken place at the quarry. The quarry site has much higher error rates than all but two other sites included in the comparative study: the Remnant site and the burial site of Njoro River Cave. The high error rates in both of those assemblages at both the Remnant Site and Njoro River Cave is driven primarily by the greater frequency of blades with multiple errors like stacked step fractures, usually a more clear sign of novice knapping (Clark 2003). However, some incidents of multiple errors, like a hinge termination and a shattered platform, may be related. The relatively smaller size of the Remnant

site and Njoro River Cave assemblages would over-represent these mistakes relative to the more consistent percentage of errors at the quarry. Another complication is the possibility that if experts are present, they may be guiding or assisting novice knapping by fixing mistakes and rejuvenating cores (Stout 2002: 702). Error rates may thus be distorted by what is, in essence, part of the teaching process. Learning is most unlikely at Njoro River Cave where there is no evidence for camping or other habitations related to its use as a mortuary site. It is difficult at present to speculate on the formation processes that resulted in the lithic assemblage at Njoro and so the origin of the high error rate here is unknown. Interestingly, both of Njoro River Cave and the Remnant site are located fairly close to Mt. Eburru, whereas more distant sites have much lower error rates in their blade assemblages.

Another line of evidence supporting learner behavior at the Elmenteitan Obsidian Quarry is the distribution of errors across blade sizes. Figure 10.2 plots the measured distribution of error rates across blade lengths against the expected patterns for novices and experts presented in Chapter 5. As discussed earlier, error rates are low for the larger and more difficult to produce blades, and then increase as cores become smaller and, theoretically, more manageable. Error rates should be concentrated earlier in a blade production sequence if experts alone are producing cores (see Bamforth and Finlay 2008; Grimm 2000; Finlay 1997; Stout 2002). The sharp spike in core error rates may reflect hand-offs from experts to novices, as expected in “scaffolding” models for lithic learning discussed by d’Errico and Banks (2015). The level of core reduction present at the quarry is well beyond what is necessary to prepare cores, and cannot be explained solely through restocking transported toolkits or provisioning tools for tasks at the quarry. In addition, diversity of core morphologies, high rates of expedient cores, and use of lower quality raw materials are all signs of lithic learning (see Milne 2013; Shelley 1990: 191). One model that accounts for all of

these patterns is that the Elmenteitan Obsidian Quarry was used as a venue for learning and practice.

Figure 10.1. Observed (red) error rate distributions compared to expected error rate distributions for different skill levels (black).

10.6.3 Composition and organization of quarrying “Communities of Practice”

It is unlikely that whole families would travel to the quarry given the basic constraints of pastoral lifeways, the impracticality of moving a herd to the Central Rift Valley or up Mount Eburru. This is evidenced by the lack of habitation sites nearby. Demands of herding and mobility would make it difficult for family units to spare multiple individuals for long distance trips at a time (Dahl and Hjort 1976). Therefore, quarrying groups were probably composed of individuals

from multiple lineages of family groups. This too is supported archaeologically in the diverse range of ceramics, likely reflecting individuals from multiple family groups, possibly even from multiple lineages. Given a heterogeneous distribution of “experts” and “novices” across the landscape, this kind of multi-community involvement might be necessary in order to facilitate the passing on of lithic reduction knowledge. Binford (2001) notes that such logistical acquisition ventures may be *ad-hoc*, however the various lines of evidence presented here are more in line with Milne’s (2013) expectations for more enduring “cooperative projects” of quarry access.

What was the social composition of these Communities of Practice? As suggested above: skill, age, and gender likely structured participation. Experimental and ethnographic evidence suggests that knapping apprenticeship usually begins between the early-to-late teens (Pigeot 1990; Stout 2002; but see Weedman 2002:738). This is typically due to the timing of motor-skill and upper body strength development (Finlay 1997, 2015; Shea 2006). Amongst eastern African herders, this is the same age that young men are ideally inducted into warrior-hood. Exact decisions about when novices would learn probably varied markedly, and would be determined by the family based on number of other children and their ages (e.g. the labor pool needed for herding), prevalence of raiding, and other practical considerations.

The role of novices at the quarry is speculative, but I suggest that it could have varied by relative age and experience in the process. For example, individuals on the first quarrying trip may have only been allowed to help extract and test nodules, with actual core preparation occurring on subsequent trips. Novices can be self-stratified within their peer groups based on internal age or inter-personal dynamics, but stratification can also be imposed on novices based on observations and judgements of accompanying experts (e.g. Stout 2002). d’Errico and Banks (2015) codify these possibilities with terms like “sequential transmission” where skills are taught in a specific

order necessary for the end goal, and “modular transmission” where several independent skills must be acquired and combined to achieve that goal. Given the demands of Elmenteitan technology, the Elmenteitan case study likely involved complex combinations of multiple transmission types. Quarrying trips could have included teaching novices important economic and ritual locations on the landscape (Binford 2001: 467), teaching them how to identify and extract obsidian, how to prepare and reduce cores, how to extract and prepare ochre, and how to make and use tools. This would reflect a more modular form of learning complex, socially embedded, tasks.

Improving our understanding of these dimensions of learning is important because it is through these kinds of learning processes that people learn how to be. Novices are enculturated through participation in the community-of-practice, which includes sharing of information well beyond lithic reduction techniques. In this way of thinking, similarities in technological signatures across the Elmentetian is evidence of a shared Community of Practice that reinforced an identity.

10.6.4 Economic importance of social institutions

Early pastoralists in eastern Africa faced environmental challenges on short and long term scales, which required active responses and adaptations. Resources were patchy and unpredictable year-to-year, rainfall cycles varied and typically included major droughts once a decade, and there were longer cycles of climatic change on the century and millennial scales (Garcin et al. 2012; Johnson et al. 2016; Nicholson 1997; Tierney et al. 2013; Weldeab et al. 2014). Elmenteitan pastoralists first appear during a period of recharging lake levels and grassland expansion in southern Kenya after 3000 BP, but faced periodic drought (Ambrose and Sikes 1991; Chritz et al. 2015; Tierney et al. 2008). Technology and subsistence strategies were certainly important dimensions of risk mitigation strategies, but even these would be embedded within broader social

systems that structured how people responded to risk (Gifford-Gonzalez 1998a, b, 2016; Marshall et al. 2011).

Given various labor, social, and political considerations, it is unlikely that every family living at every Elmenteitan site would be able to send representatives or work parties to the quarry at any time when a new supply of obsidian might be needed. Therefore, Elmenteitan communities would have on relied on reciprocity and mutualistic exchange to ensure regular access to obsidian. I suggest that when one community was able to send groups to the quarry directly, they would have been responsible for managing the secondary distribution of obsidian cores to surrounding groups. This form of reciprocity is one of the most fundamental dimensions of human social alliance and economic security (Mauss 1954; Wilk and Cliggett 2007).

This process could, occasionally, be integrated into events like marriages or age-grade rituals. Atypically large Elmenteitan sites like Ngamuriak, where there is abundant evidence for direct access to large cores could, for example, represent “*manyatta*” like habitations, where many descent groups and families aggregated for ceremonial purposes. Such gatherings would be convenient venues for obsidian redistribution, and supplying that obsidian may have been an expectation for the group hosting social aggregations. Deviations from a normal distance-decay model for core access could be the result of this “shifting access” system with multiple pathways for acquiring and moving obsidian between communities across time and space.

Rather than emphasize small-scale community level decision making and mobility, the evidence of archaeological patterns at the Elmenteitan Obsidian Quarry and the results of analyses of technological analyses suggests that this group responded to risk through intensification of social alliances built on mutualistic exchange and social institutions that reinforced group identity. There are several reasons why such a strategy might be beneficial. Dyson-Hudson and Smith

(1978: 22) observed that increased information sharing is important when resources are unpredictably distributed. Networks of exchange and the participation of diverse communities in quarrying would provide venues for distributing information about rainfall patterns, wild herd migrations, livestock diseases, and other important events. Establishing long-distance relationships and/or maintaining social alliances also ensures groups experiencing a drought have grazing access in areas that did receive rainfall (Dahl and Hjort 1976; Spencer 1973). These relationships are what Carolyn Lesorogol (2003) calls the “moral economy” of networks built on reciprocity that allows herder communities to “remain pastoralists” during major droughts and other disasters. Even the Maa language reflects the importance of “*o-sotua*”, meaning stock-friend, but which also translates to “umbilical cord”, “kinship”, and “peace” (Hughes 2016). In the past, the importance of access to high quality lithic material may have allowed obsidian-friendships to be equally important or, more likely, obsidian exchange provides an archaeologically visible correlate for complex webs of social interaction that permitted the long-term stability of pastoralist lifeways.

Historically, long term viability of pastoralist lifeways in arid regions with unpredictable rainfall depends on the existence of such socially mobilized networks. Perhaps the delays in the transmission of herding through eastern Africa proposed by Gifford-Gonzalez (2000, 2015) were due to a lack of such networks, or their nascent instability. I suggest that perhaps deployment of a stronger integrated alliance or exchange system, and the social structures behind it, helped sustain the later expansion of Elmenteitan groups throughout southern Kenya and into the Lake Victoria region. Application of new methods and research projects can help to examine this proposition and to trace the prehistoric movement livestock, beadwork, pottery, and especially geochemically distinct sources of lithic raw material. In this way, we can better understand patterns of resource acquisition and distribution, and how they contributed to trajectories of food production in Africa.

10.7 Summary

Archaeological and spatial patterns support a communal access model to the Elmenteitan Obsidian Quarry, and clues from comparative analysis of Elmenteitan lithic assemblages suggest the existence of a cohesive obsidian long distance exchange and distribution system (see Ambrose 2001). Inspired by the discussions of these possibilities posed by Robertshaw (1990), Ambrose (2001), Gifford-Gonzalez (1998), and Marshall et al. (2011), this research project disputes the idea for hierarchical control of the quarry source, and thus the existence of discernable social inequalities among early herders in southern Kenya. Instead, I use archaeological data, environmental context, and ethnohistoric comparisons to present an alternative model for obsidian quarrying. I argue that diverse Elmenteitan groups participated in obsidian quarrying, transport, exchange, and distribution through formalized social institutions.

The exact form and organization of such institutions is only speculative, but it likely operated in a comparable way to the age-grade institutions of recent herders, or at least filled a similar socio-economic niche. At least at present, there are a few parallels to support this comparison. Expanding on this model, I have attempted to contextualize quarrying strategies within the broader social world of pastoralists in a region with high environmental risk on short, medium, and long timescales. Communities of practice involved in quarrying could have played an important role within the kinds of socially driven risk-mitigation strategies that have been so important for recent pastoralists' livelihoods. Elmenteitan strategies were certainly far more complex, with reciprocity, alliance building, and resilience having taken on many forms. Quarrying institutions form only one dimension that happens to have much higher archaeological visibility.

Excavations at the Elmenteitan Obsidian Quarry provide only initial clues for how exchange networks were organized by Elmenteitan producing herders. If further work supports the access models postulated here, it is possible to begin integrating gender, age, and social identity into discussions of the Pastoral Neolithic. This has been a long-standing goal of archaeologists working in the region (Ashley and Grillo 2015; Gifford-Gonzalez 1998b, 2005; Lane 2004; Marshall et al. 2011; Prendergast 2009; Simons 2005). Even though a direct control model may be unlikely in light of this evidence, Robertshaw (1990) drew attention to the important value of obsidian access and its potential social consequences within the Elmenteitan. Rather than a single community controlling access, groups with more reliable or consistent access to the quarry could still have leveraged that ability in complex ways. With the Elmenteitan Obsidian Quarry assemblages as the point-of-origin datum, new research projects can test these hypotheses and expand models for the social dimensions of early pastoralist exchange in the region.

Chapter 11

CONCLUSIONS

This dissertation is my effort to combine archaeological excavations with a regional comparative lithic analysis to build upon social and economic models for early pastoralist strategies in eastern Africa. I have focused on reconstructing the lithic technological organization of the Elmenteitan cultural entity in southern Kenya as it pertains to major themes of research within the broader study of African pastoralism, including early herder mobility, risk mitigation strategies, herder social institutions, and especially the structure of raw material exchange systems. All of these dimensions of early herder lifeways are deeply intertwined, and so I have presented a holistic analysis that engages with a full range of social and the economic theories and models for understanding lithic technological variability. I have applied this analysis to understand an entire system of lithic production, on a regional scale. At the literal and figurative core of this endeavor is the archaeological research project at the Elmenteitan Obsidian Quarry. This site was the staging grounds for an obsidian distribution system that supplied Elmenteitan technological strategies, and reinforced cultural identities and social connectivity across southern Kenya.

Results from the archaeological analysis centered on this key quarry site and the surrounding landscape reveal a highly organized pattern of communal access within the Elmenteitan, suggesting a high degree of social investment and integration. In Chapter 7, I present a technological analysis of lithic material recovered from excavations at the quarry that indicates intensive processing and core reduction took place there. I expand this analysis in Chapter 8 to compare the pattern at the quarry to twelve other Elmenteitan assemblages distributed across the landscape, and to the Savanna Pastoral Neolithic site of Narosura. I argue that Elmenteitan

technological strategies are consistent across sites of different types, from different time periods, and from different region, with fluctuations and deviations that may be reflect specific social or ecological circumstances. Elmenteitan lithic strategies likely developed within the context of ecological and environmental unpredictability. The lithic technology itself appears oriented around maximizing flexibility and adaptability of the toolkit and blade blanks, ensuring Elmenteitan economic strategies could be maintained in the event of rapid ecological, environmental, and socio-political change. I conclude that there is a quantitative basis for defining Elmenteitan technology, largely in terms of the variables identified by Ambrose (1980, 2001) and C. Nelson (1980).

Consistent access to obsidian from Mt. Eburru played an important role in maintaining this technological pattern, and I use the results of the analyses to refute the hypothesis for centralized quarry control, and to propose an alternative model for obsidian access and distribution that involves organized social institutions and reciprocity-based exchange networks. Regional participation within an obsidian exchange and distribution system maintained social bonds, stock-partnerships, and identity-based alliances that allowed Elmenteitan herders to disperse risk through complex interpersonal networks. I argue that these strategies were responsible for the long-term success of Elmenteitan herders in southern Kenya, and similar techno-social systems may have played an important role within many phases of the spread of mobile herding throughout Africa.

In this conclusion, I discuss the important theoretical and methodological insights resulting from this project, and I revisit my research questions to present final thoughts on the nature of early pastoralist technological systems.

11.1 Methodological perspectives

I have presented research focused on two scales- that of a single special purpose quarrying site, and the total Elmenteitan landscape. At the site level, I collected abundant data relating to spatial organization of activities, and the material products related to those activities. The Elmenteitan Obsidian Quarry is the first Holocene lithic quarry to be systematically studied in eastern Africa, and one of the few Pastoral Neolithic (c. 3200-1400 BP) sites in southern Kenya to have been excavated and reported in the last decade. It includes a large lithic assemblage, as well as a surprisingly large ceramic and faunal collection for a quarry site. The spatial divisions I was able to detect were stark, but coarse. More excavations across the site would be important in further understanding the spatial structure of activities at the site, and these relate to the social institutions involved in quarrying I have proposed.

Archaeological work at the Elmenteitan Obsidian Quarry confirms the potential, and indeed the importance, of quarry archaeology for research in Holocene African. The frequency of quarry sites used by diverse forager and food-producing groups in the Central Rift Valley offers unique opportunities to explore the connections between quarrying behaviors and broader economic and subsistence strategies (see Ambrose 2012; Brown et al. 2013; Merrick and Brown 1984). Quarry use and long-distance transportation of obsidian appear to be important developments in the emergence of our species (Blegen 2017), and their relationship to changing environments and exploitation strategies have been specifically discussed by Ambrose (2012) for East African contexts. Further developing these models across time and space requires more attention to ancient lithic quarries and workshop sites. This dissertation contributes only a small part to a large literature that demands we consider quarries places of social (re)production, and

take care to look for spatial and material differences across, and through, quarry deposits (Beck et al. 2002; Binford and O'Connell 1984; McCoy et al. 2011; Purdy 1984).

I have also stressed the phenomenological importance of Mt. Eburru on the landscape, and I do not hesitate to speculate that the highly atypical use of obsidians from its upper slopes may have been motivated by ritual or cultural importance of the mountain itself. Just as is being recognized for ochre (Zipkin 2015), symbolism and culture can shape how humans make choices about lithic raw material sources.

The case-study of the Elmenteitan Obsidian Quarry also demonstrates the need to interpret raw material exploitation within the broader patterns of settlement and land-use. The limited surveys possible within the scope of this project confirmed that there was little evidence for large-scale open air habitations around the quarry as would support hypotheses for centralized control of obsidian access and exchange (Robertshaw 1990). My interpretations of quarry use are also shaped by the peculiar abundance of Elmenteitan rockshelter and burial sites, but paucity of Elmenteitan open-air settlements, in the Central Rift Valley. These lines of evidence also fit with a less centralized form of quarry access. The overall pattern fits better with Ambrose's (2001) proposal for a regional distribution network.

Finally, the quarry as a dataset becomes most valuable when compared against existing Elmenteitan assemblages across the landscapes (Ambrose 1980, 1984b; Bower et al. 1977; Lane et al. 2007; Nelson 1980; Robertshaw 1990, 1991). Analysis of the full technological system traced out from its origin at the quarry was necessary for a quantitative assessment of Elmenteitan lithic traits and core design strategies. Only by comparing Elmenteitan sites against the obsidian quarry was I able to present a case for regional consistency and stability in Elmenteitan technology.

There are, of course, opportunities for future study at the site or regional levels to refine or refute my interpretations for the Elmenteitan Obsidian Quarry. I was only able to recover datable charcoal from a single portion of the site, and these revealed rapid deposition in that area. General consistency across the site (controlling for differences in phase of reduction), and indeed consistency across time and space, does suggest variability in any part of the broader technological organization was limited. Even so, these must be treated as hypotheses to be tested. Use of the quarry site may have changed through the nearly 2000 years Elmenteitan groups used obsidian from Mt. Eburru. Limited excavations and limited dating would have prevented me from identifying such changes. This same argument holds for the regional interpretations. There are too few existing Elmenteitan sites spread across too many ecological zones and across too much time to be able to fully rule out that variability for lithic attributes noted in Chapter 8 are not due to local environmental conditions. Pastoralism in eastern Africa is, historically, defined by economic flexibility in the face of uncertainty. I have argued that deviations in certain blade attributes or morphometrics at particular sites represent these kinds of localized problem solving. Additional excavations and improved analyses should help determine if there is regional variation that I was unable to detect, or if technological variation can be correlated with any specific set of environmental stresses.

Lithic technological organization (TO) has proven to be a productive framework for studying the economic structures of stone-tool using populations in the past, especially as they relate to raw material access, mobility, and environmental adaptation (Andrefsky 1994b, 2004, 2010; Bamforth and Bleed 1997; McCall 2012; Nelson 1991; Shott 2015). In this dissertation, I have combined quantitative and qualitative analyses of blade attributes and morphometrics to reconstruct trajectories of blade core preparation and reduction. Using this data to explicitly test

models for how obsidian was accessed, transported, and distributed, within the Elmenteitan contributes a large dataset for exploring how technologies function within a *pastoralist* economy, wherein mobility and raw material access were structured very differently from forager or farmer economies. It is my hope that the datasets developed here provide a template for expanding this study in analyzing pastoralist technologies and economies elsewhere in eastern Africa.

One conclusion of this analysis is that methodologies developed in the context of mobile/sedentary dichotomies, and primarily in reference to hunter-gatherer economies, can be adapted to study pastoralists, whose mobility is contingent on the needs of livestock. A lithic technological organization framework has allowed me to make inferences for Elmenteitan mobility strategies, highlighting the potential of lithics (the most abundant dataset available from early herder sites) in testing hypotheses on ancient pastoralist mobility.

Furthermore, my analysis finds no evidence of technological change that might indicate increasing technological investment in cultivation or agriculture through the Elmenteitan sequence, until c. 1400 BP at the Deloraine Farm site (Ambrose 1984b). Ehret (1980) has argued for cultivation based on linguistic reconstructions, however the standard for asserting plant use remains the positive identification of botanicals remains (Young and Thomson 1999). I do not contest a substantial degree of wild plant utilization, but my findings suggest that significant grass harvesting did not occur until much later, when macro-botanical evidence begins to appear archaeologically (see Wetterstrom 1991). Absence of evidence is not evidence of absence, and future research on lithic use wear, residues, and especially paleobotany, may prove that more intensive wild or domesticated plant harvesting did occur, and so would have played a role within Elmenteitan technological organization.

Discussions of lithic technology have emphasized the importance of social and cultural factors in technological strategies, however there have been few attempts to actually investigate these connections. This has been especially true in eastern Africa, where there have been few region-wide comparative quantitative studies of lithic assemblages. This project has attempted to build on the foundational analytical projects of Ambrose (1980, 2001), Gifford-Gonzalez (1998a,b) , C. Nelson (1980), and Robertshaw (1988) in exploring the role of technological systems and patterns in broader social and economic lifeways among Elmenteitan communities. I have presented preliminary models for reconstructing these cultural systems from available lithic datasets, and I have argued that these culturally driven systems were not epi-phenomenal, but played a vital role in the long term resilience of herding lifeways in eastern Africa.

I have used a preliminary assessment of skill in an attempt to begin building a bridge between quantitative variation in lithic attributes and the social context that affected variation in these attributes. The findings from Remnant are a good example of why this perspective is important. Blades from Remnant exhibit both the highest rates of production errors and several morphometric deviations from the other Elmenteitan blade assemblages. Evaluating skill, however coarsely, is important for determining what lithic variation may be attributed to behavioral responses to specific ecological or climatic conditions, and what is a product of cultural process.

People had to learn about the location of lithic resources, how to extract them, how to prepare cores, and how to reduce those cores, and knowledge is differentially distributed within a community, often along the lines of age, gender, and lineage. Admitting that learning occurred in the past necessarily requires us to evaluate these ‘communities of practice’ and the social structures in which they are embedded. I have speculated on how lithic learning may have been

integrated into the system that maintained connectivity between Elmenteitan communities as discussed by Ambrose (2001) as a reason for the remarkable homogeneity in material culture and obsidian selection amongst this group. I have added a description of the Elmenteitan technological operational sequence to the list of characteristics maintained by Elmenteitan communities through time and across space as a part of their specific strategy for managing the risks associated with mobile herding in the environments of southern Kenya. Given that *Homo sapiens* universally exhibit complex and deeply cultural patterns of knowledge transmission (d'Errico and Banks 2015), attempts to identify novices in the archaeological is not only important for interpreting variation in the technologies associated with the spread of pastoralism, but also for all studies of lithic assemblages in the last 200,000 years.

As much as this dissertation may have revealed about the Elmenteitan, this only raises more questions about patterns across the Pastoral Neolithic. A major limitation of this project is that time constraints prevented a comparison of the Elmenteitan technologic organization to comprehensive analyses of the SPN, Eburran V, and Kansyore. Narosura proved a valuable out-group sample, but it does not represent the whole of the SPN, which is known to be relatively more diverse in its technological signatures (Ambrose 2001). While this research has partially confirmed differences between the SPN and Elmenteitan, a similarly regional comparative analysis of SPN lithic assemblages is needed to quantitatively understand the different technological strategies within that group. Likewise, Elmenteitan datasets must be compared against the Eburran V and other hunter-gatherer assemblages from southern Kenya to fully explore what aspects of technology might be uniquely derived among pastoralists in the region. Future research should also explore the termination of the Elmenteitan technologies and obsidian exchange systems, and

the broader social and cultural institutions attached to them, when iron technology spreads into the region after c.1500 BP.

If the social institutions proposed here did exist in the past, the abandonment of stone in favor of metal would have had significant repercussions for herder identities and existing forms of social risk-mitigation built around obsidian quarrying and distribution. This transition may have shaped how Elmenteitan populations responded to subsequent expansions of herders in Kenya, or even encouraged the development the more recent forms of pastoralist social institutions that have existed ethno-historically (see Spear and Waller 1993).

11.2 Theoretical perspectives

In conducting this research I sought to develop a holistic perspective of a complete technological system. As I have discussed previously, this necessitates a comparative analysis on a landscape level, including quarries, but it also requires the application of diverse anthropological theories that consider social dimensions of human technologies. It is true that social and cultural practices and institutions have always had a seat at the interpretive table in lithic studies (e.g. M. Nelson 1991), but too often they remain un-filled. Archaeologists have instead preferred *optimal foraging* frameworks, wherein technologies are efficient adaptations to environments, and social systems exist only to facilitate optimized strategies (see Surovell 2009). This has been especially true in pastoralist archaeology, wherein social organization is often seen as conditioned by mobile lifeways, which in turn are a response to environmental conditions.

I argue, as have Grillo (2012), Gifford-Gonzalez (1998b), Marshall et al. (2011) and others, that social and cultural factors actively shaped pastoralist economies. I support a different causal trajectory, wherein social systems shaped mobility strategies, in turn shaping technologies, and in

turn shaping the lithic assemblages recovered and analyzed by archaeologists. While environmental conditions are absolutely the foundation for any interpretation of a lithic assemblage, as Bruce Trigger observed (paraphrasing V. Gordon Childe) “Human beings adapt not to real environments, but to their ideas about them, even if effective adaptation requires a reasonably close correspondence between reality and how it is perceived” (1989: 261). Strategies, relationships, and networks that formed around obsidian quarrying and regional exchange may have arisen as a means of bet-hedging and risk mitigation facing environmental uncertainty, but their form and structure were determined by real human people making social choices.

Evidence for this is readily available in the Pastoral Neolithic of southern Kenya. Archaeology of the Savanna Pastoral Neolithic and Elmenteitan groups suggests very different lifeways and means of organization, despite occupying the same environments and facing the same climatic changes, with fundamentally similar economies, through the same time range (Ambrose 2001). Furthermore, despite lasting for nearly 2000 years, both the Elmenteitan and SPN strategies eventually stopped being advantageous, and disappeared. The technological data presented here show that Elmenteitan strategies persisted through extreme climatic fluctuations and yet material signatures begin to fade during a period of ameliorated climate after ~1500 BP (Verschuren et al. 2004). Despite the strong association of pastoralist lifeways with environmental conditions, the end of Elmenteitan (as well as the SPN) traditions seems to have more to do with the incursion of iron technologies, agricultural lifeways, new populations, and changing socio-cultural dynamics.

This is not to throw the baby out with the bathwater; I argue that the focus should be re-oriented toward understanding how individual herder communities managed the specific ecologies in which they lived. Environmental unpredictability is important, clearly structuring the technological organization and toolkit design of Elmenteitan pastoralists, and it is often used to

explain the structure of modern pastoralist strategies (N. Dyson-Hudson and R. Dyson-Hudson; Grillo 2012; Marshall et al. 2009; Western and Dunne 1979). In order to actually test these ideas it is necessary to understand how pastoralists, ancient and modern, actually deploy material culture in response to different conditions. Eastern Africa encompasses a wide range of ecological zones with complex plant and animal ecosystems that each respond differently to regional climate change. This is further complicated by the increasing evidence that ancient Africans have been modifying their landscape for thousands of years, affecting long-term ecological trajectories (Boivin et al. 2016). The net effect is a shifting mosaic of plant and animal resources and distributions. The archaeological remains of pastoralists reflect how one community was exploiting the specific ecological patch(es) in which they lived at that specific point in time. So the issue is not “how did pastoralists respond to changes in the environment” but rather “how did pastoralists engage with changing ecologies within their environment”. It is a subtle, but important, distinction that highlights the need for more refined, localized, paleo-environmental and paleo-ecological studies for interpreting Pastoral Neolithic sites and artifact assemblages.

Foundational efforts connecting ecological reconstruction and human adaptation were undertaken at Eburran hunter-gatherer sites by Ambrose (1984c), and more recently Chritz et al. (2015) have employed isotopic datasets to reconstruct ecological conditions around the Elmenteitan sites of Gogo Falls. If these efforts can be expanded, especially by further integration of geoarchaeological methods, isotopic analyses, and palynology, it will better inform archaeological interpretations of ancient herder sites. If, as I have argued, pastoralist mobility strategies varied depending on conditions and available resources, it should be possible to connect archaeological correlates for mobility with the specific ecological constraints or opportunities that existed at a particular site. This also presents opportunities to understand under what conditions

individual herder families engaged in plant cultivation, wild animal hunting, trade and exchange, or the kinds of specialized pastoralism noted for the Elmenteitan at Ngamuriak (Marshall 1991) and Sugunya (Simons 2004).

Interpretations are inherently structured by the theoretical frameworks archaeologists apply, and current models for early pastoralists in southern Kenya can be improved through better integration of ethnohistoric and ethnographic structural analogies (following Wylie 1982, 2002). East African pastoralist archaeology has long benefited from a wealth of high quality ethnographic research on living pastoralists systems in similar environmental contexts. Recent actualistic projects with targeted archaeological questions have proven especially useful for building empirical models of ancient pastoralist lifeways (Biagetti 2014; Grillo 2012; Shahack-Gross et al. 2003; Weissbrod 2011; Woldekiros 2014). However, the abundance of local analogical options should not discourage looking to pastoralist systems in other parts of the world for interpretative inspiration. Ethnoarchaeological and anthropological research on pastoralist systems in the Andes (Aldenderfer 2001; Browman 2008) and Central Asia (Frachetti 2008) are revealing the same forms of social complexity and landscape level interactions that have long been observed in eastern Africa (Fratkin 1986; McCabe 2004; Spencer 1965, 1973). Ideas from these contexts have greatly improved the interpretations presented for the Elmenteitan data in this dissertation. In turn, the development of a socially informed archaeology of pastoralism in Africa must be explicitly oriented toward a growing global audience interested in the complexity of pastoralist lifeways.

11.3 Lithic Technology and the Spread of Food Production in Africa

Use of stone tools long predates the transition to food production. It is a behavior that is both universal, and central, to the human experience. The development and adoption of food

production by hunter-gatherers is associated with major reconfigurations of technological strategies and social systems (Ambrose 1998; Bradley 2004; Capriles 2011; Marshall and Hildebrand 2002). Archaeological investigations in Europe, the Near-East, and North America attribute technological changes primarily to shifts in mobility strategy and patterns of raw material acquisition that result from increased investment in cultivation or agriculture (Andrefsky 1994; Bar-Yosef 1998; Kelly 1992; Lemmonier 2013; Shott 1986). Transitions to economies based on herding domesticated livestock likely required structural changes to lithic technological organization as well, although these trajectories may have been quite different from those observed for the origins and spread of agriculture. I have presented an archaeological investigation of Elmenteitan lithic organization as a case study for how lithic technological changes can be identified and understood in the context of African pastoralism.

In order to explore how technological strategies were manipulated by Elmenteitan pastoralists in southwestern Kenya I have combined datasets on several scales. Spatial, artefactual, contextual, and technological data from the Elmenteitan Obsidian Quarry itself inform the strategic and social dimensions of raw material acquisition. Comparative analysis of Elmenteitan blade assemblages from across southern Kenya demonstrates the reliability of Elmenteitan obsidian distribution and the uniformity of Elmenteitan technological organization across diverse environments. This is the first study in the region to quantitatively describe the entire system of lithic acquisition, distribution, and reduction, using data from such a large number and wide range of sites belonging to a single pastoralist culture group.

My analysis of Elmenteitan blade assemblages has led me to two major conclusions about the role of lithic technology in the spread of pastoralism into southern Kenya. First, there are different strategic options available to pastoralists facing the same environmental challenges and

opportunities, and the Elmenteitan pastoralist phenomenon exemplifies a strategy that emphasized flexibility and versatility but required more time and energy investment in the early stages of core reduction.

Second, the raw material exchange systems that supplied high quality obsidians to the sites sampled here, however informal they were, were an important part of the fabric of relations that connected Elmenteitan communities. The remarkable contrast between the highly variable raw material selection patterns and technological strategies of Holocene hunter-gatherers, and the uniformity within the Elmenteitan, hints at just how different the social structures of herding societies were. It may be that, within eastern Africa, the formation of these cohesive “networks” is a particular trait that can be used to trace the spread of pastoralism. Changes in raw material selection and technological strategy may signal the ephemeral extension of herders into new regions, or the establishment of relationships with hunter-gatherers, before they might be otherwise detected archaeologically. For example, recent obsidian geochemical sourcing work on Kansyore hunter-gatherer sites near Lake Victoria has identified a large increase in access to obsidian from Mt. Eburru during the Pastoral Neolithic, presenting some of the strongest evidence for interaction between Elmenteitan and Kansyore groups (Frahm et al. 2017).

Evidence for long distance obsidian acquisition among early herders living around Lake Turkana (Ndiema et al. 2010) and in Tanzania (Prendergast et al. 2013) illustrates that the existence of regional interaction systems was a major part of pastoralist technological organization throughout the region. This is a vitally important step in moving beyond the typological approach to pastoralist lithic assemblages that is still common in many parts of Africa.

I have argued that the reason some pastoralists developed strategies of long distance material provisioning and consistent technological strategies was, in part, to build and maintain

social bonds between communities. Webs of relationships and reciprocity help ensure pastoralist resilience in unpredictable environments today, and could have been important in the past (Berntsen 1979; McCabe 2004; Schneider 1972; Spear and Waller 1993). Modern pastoralists themselves attest to the importance of these systems. For example a Pokot elder recounted an instance where, on the verge of starvation following a series of Karamajong raids, he invoked his family's networks of stock-partners;

“Three of my brothers and I journeyed around the entire countryside trying to accumulate stock. One stock associate gave us goats, another cattle, another goats, and so on. After two extensive trips we had gathered 21 cattle and 39 goats. They were enough to save the family.”

-Robbins (2006: 255)

It is precisely these kinds of simple relationships, person-to-person, and family-to-family, that build the often cited resilience of pastoralism in arid environments (Western and Dunne 1979). Generalizations about climatic regimes and livestock management strategies are important, but ultimately the spread of herding was built by individual social acts. While I have argued that there is evidence for individual communities accessing obsidian directly, I doubt that the distribution of obsidian among Elmenteitan communities was an entirely independent process. Rather, it was likely embedded within larger systems in which livestock, plant foods, medicines, organic and ceramic vessels, adornment and beadwork, and ritual paraphernalia, were moving between Elmenteitan families and friends. Obsidian could have been given as gifts between stock-associates, distributed at weddings and other ceremonies, and exchanged between herders and

foragers. In a period before metals, most people likely had to learn how to make stone tools to some degree, and acquiring high quality stone had considerable importance.

New techniques are making it possible to detect these relationships archaeologically. Testing this model with larger sample sizes from more sites, isotopic analysis, and ceramic sourcing studies is necessary. Whether or not these ideas hold up to new evidence, I sincerely hope that they stimulate new discussions of pastoralism that consider the deep entanglements of environment, economy, and culture that are inherent to this way of life.

11.4 Concluding Thoughts

Pastoralism remains one of the economically important lifeways in Africa today. As resilient and productive as pastoral economies have proven to be in arid and semi-arid environments, these lifeways are under constant threat. Climate change, urbanization, political and ethnic conflict, agricultural and industrial development, and diminishing biodiversity are all limiting the options available to pastoralists, endangering the flexibility that has been central to these ways of life through history (Homewood 2008). These threats are on an unprecedented scale, but archaeology demonstrates that people have survived similar stresses in the past. Today, East African herders are again turning to participation in formal and informal trade and exchange across diverse groups and communities in response to climatic and social change. These trade networks are estimated to involve the transfer of around \$1 billion per year (Catley and Schoons 2012). This is a testament to both the importance of small-scale exchange in long term sustainability of herders, and also to the interwoven fates of pastoralists, farmers, and urban communities in Africa.

Ensuring the resilience of pastoralist lifeways is ultimately in the hands of pastoralists themselves. Foreign intervention and aid efforts have had mixed success. They often proceed from

misconceptions about the relationship between herders and their environments, and impose western biases on long-term cultural practices (Davies 2008; Homewood et al. 2012). I conducted this research during a time of vocal skepticism about NGO's by the Kenyan government and the Kenyan people concerning their failure to deliver on promises of improved access to education, especially in rural areas. Pastoralists recognize the threats they face, and have the knowledge and capacity to respond effectively. Despite the popular conception that they are economic specialists, their responses to a globalizing world constitute only the latest in a long history of opportunistic economic re-alignments (Hodgson 2012; Spear 1993). Even so, there are enduring anxieties about the future. Technological innovations that facilitate connectivity and cooperation between communities, and ensure the transmission of knowledge to subsequent generations, will be vital for the future of pastoralism, just as they were in the past.

Archaeology has a great deal to offer dialogues on the future of African pastoralism (after Honeychurch 2010). Archaeological investigations are the only means of understanding the deep-time impacts that herders have had on ecological and social landscapes, and how herders have responded to major episodes of climate change that are beyond historical memory. East African pastoralists are well aware of the importance of maintaining livestock biodiversity (Mapinduzi et al. 2003), and the Food and Agriculture Organization of the United Nations has more recently highlighted the importance of livestock biodiversity in facing climate change (FAO 2015). Zooarchaeology, proteomics, residue and isotopic analyses, bioarchaeology, and ancient DNA studies are providing new perspectives on ancient herd composition and management strategies that are relevant to the present. Studies of material culture provide a complementary perspective on what I argue is an equally important dimension of pastoralism; the ontologies of identity that underlie and re-inforce peoples dedication to this important way of life.

APPENDIX I: Level descriptions for excavation units at the Elmenteitan Obsidian Quarry (sterile Area 3 units not included)

UNIT 1 E4414, N0211 2586 m asl									
Start of level (cm below surface)						Sediment description			
Lvl	NW	NE	SE	SW	C	Munsell	Texture	Inclusions	Notes
0	15	18	14	12	14	10YR 2/2	Loam	crushed debris, roots	overburden/ agricultural surface
1	25	27	26	23	25	5YR 2.5/1	Loamy-clay	rounded pebbles [r], roots [vc]	plow zone, few artifacts
2	34	38	33	31	34	7.5YR 2.5/2	Clay-silt	angular obsidian & tuff [r]	stopped at natural level break, increase in artifacts
3	45	45	45	41	42	7.5YR 2.5/1	Clay-silt	angular pebbles [c], mica granules [c] angular, subangular tuff [r], Sub-rounded & sub-angular	natural level break- encountering dense lithic surface
4	55	55	52	51	55	7.5YR 2.5/1	Silty clay	obsidian [c], large root cavity angular, subangular tuff [r], Sub-rounded & sub-angular	dense lithic material, ceramics, fauna
5	66	67	65	63	65	7.5YR 2.5/1	Silty clay	obsidian [c], roots	artifact density decreasing
6	79	79	75	79	79	5YR 2/2	clayish silt	Subrounded & subangular volcanics [c]	few artifacts, some charcoal
7	93	92	92	91	92	5YR 3/3	clayish silt	None	Few lithics, translocated down root cavities
8	101	104	102	102	104	7.5 YR 4/4	clayish silt	Angular volcanic cobbles [r]	heavily compacted, artifacts rare
9	115	112	116	114	113	7.5 YR 4/4	silt	large pumice cobbles [r], subrounded & subangular volcanics	Increasingly fine sediments, increasing volcanic inclusions
10	132	134	130	130	130	7.5 YR 3/2	Silty clay	[c]	encountered ash layer
11	158	156	156	157	158	10YR 5/4	ash	Subrounded & subangular volcanics [vc]	compacted ash layer
end	162	164	160	161	162				
Unit 2 E4431, N0199 2583m asl									
0	13	18	15	9	16	10YR 2/2	loam	crushed debris, roots	overburden/ agricultural surface
1	20	23	23	22	20	10YR 2/1	loamy silt	rounded pebbles [r], roots [vc]	plow zone, few artifacts
2	29	28	29	28	28	10YR 2/1	loamy silt		artifact density low
3	38	38	37	36	38	7.5YR 2.5/1	silt	Decayed organics, large burrow in center/sw	semi-compacted, artifact density low
4	55	53	53	54	53	7.5YR 2.5/1	silt	Decayed organics (fewer), large burrow in center/sw	semi-compacted, sterile
end	64	60	61	62	60				
Unit 3 E4415, N0211 2586 m asl									
0	13	20	17	9	14	10YR 2/2	Loam	crushed debris, roots	overburden/ agricultural surface
1	23	23	19	19	20	5YR 2.5/1	Loamy-clay	subrounded, subangular volcanics [r], organics, roots	few artifacts
2	33	30	30	31	29	7.5YR 2.5/2	clay-silt	subrounded, subangular volcanics [c], organics, roots	increasing density of materials
3	45	45	42	42	44	10YR 2/1	clay-silt	subrounded, subangular volcanics [c], mica granules [c]	dense "surface" of lithics

Start of level (cm below surface)						Sediment description			
Lvl	NW	NE	SE	SW	C	Munsell	Texture	Inclusions	Notes
4	50	50	47	52	51	10YR 2/2	silt	subangular obsidian cobbles [r] angular, subangular tuff [r], Sub-rounded, sub-angular obsidian	compacted layer, bottom of arch. horizon
5	58	55	56	60	56	10YR 2/2	silt	[c], small roots	artifacts rare
end	65	66	63	64	62				
Unit 4	E4475, N0172	2589m asl							
0	18	16	10	7	12	10YR 2/2	loam	crushed debris, roots	overburden/ agricultural surface
1	38	37	38	38	36	10YR 2/1	loamy silt	rounded pebbles [r], roots, organics	few artifacts
2	45	46	49	44	47	10YR 2/1	clay-silt	rounded pebbles [r], roots, organics	sterile, no artifact horizon
end	58	57	52	55	57				
Unit 7	E4415, N0207	2589 m asl							
1	0	0	1	3	1	10YR 2/2	loam	crushed debris, roots	overburden/ agricultural surface
2	20	22	19	17	21	10YR 2/1	loamy silt	roots, organics, rounded pebbles [r], subangular & subrounded obsidian [r] mica granules [c], organics, subrounded & subangular volcanic	lower plowzone
3	33	31	31	32	32	10YR 2/1	silt	[r]	semi-compacted, few artifacts in SE and NW corners
4	38	38	37	38	39	10YR 2/2	silt	angular & subangular volcanics [c], organics, lava cobbles [r]	slight dark area surrounded by cobbles in NE corner
5	46	47	47	44	45	7.5YR 2.5/1	silt	angular & subangular volcanics [c], small burrows	surface of lithic horizon, abundant pottery, mottled soil color
6	48	50	51	48	49	7.5YR 2.5/1	silt	subangular volcanic cobles [r], volcanic pebbles [c]	dense lithic materials, thicker than Units 1,3
7	54	57	57	54	55	10YR 2/1	silt	subangular volcanic pebbles & granules [c], thin roots	lithic surface, stopped at natural level (color/texture change)
8	59	59	59	60	60	10YR 3/2	clay-silt	subangular & angular volcanic pebbles [c] & cobbles [r]	natural level break- continued excavation through lithic surface
9	63	62	62	61	63	10YR 3/2	clay-silt	subangular & angular volcanic pebbles [c]	semi-compacted to compacted, material still common
10	66	66	67	66	66	10YR 3/3	silt	subangular & angular volcanic pebbles [c] & cobbles [r]	compacted, artifact density decreasing
11	69	69	71	70	70	10YR 3/3	clay-silt	subangular & angular volcanic pebbles [c] & cobbles [r]	compacted, sterile except for small translocated frags
end	75	74	76	76	76				
Unit 8	E4415, N0206	2589m asl							
1	0	1	2	1	1	10YR 2/2	Loam	organics, roots, crushed artifacts, potatoes	overburden/ agricultural surface
2	14	14	12	12	12	10YR 2/1	loamy silt	roots, organics, rounded pebbles [r], subangular & subrounded obsidian [r] mica granules [c], organics, subrounded & subangular volcanic	lower plowzone
3	23	21	20	21	23	10YR 2/1	silt	[r]	organic darker layer beginning- same as previous units
4	32	29	30	20	29	10YR 2/2	silt	angular & subangular volcanics [c], organics	encountered surface of arch level

Start of level (cm below datam)						Sediment description			
Lvl	NW	NE	SE	SW	C	Munsell	Texture	Inclusions	Notes
6	45	46	46	45	45	10YR 2/1	silt	subangular volcanic cobbles [r], volcanic pebbles [c]	less mottled, frequent pot sherds , very large blades and flakes
7	50	50	51	51	49	7.5YR 2.5/1	silt	subangular volcanic pebbles & granules [c], thin roots	dense lithic materials, thicker than Units 1,3
8	54	57	57	54	55	10YR 3/2	clay-silt	subangular & angular volcanic pebbles [c] & cobbles [r]	lithic surface, stopped at natural level (color/texture change)
9	59	60	59	57	58	10YR 3/2	clay-silt	subangular & angular volcanic pebbles [c]	natural level break- continued excavation through lithic surface
10	62	62	62	61	62	10YR 3/2	clay-silt	subangular & angular volcanic pebbles [c] & cobbles [r], large root cavity in sw corner, mica granules [r]	more compacted sediment, decreasing artifact density
11	68	67	66	65	65	10YR 3/3	silt	subangular & angular volcanic pebbles [c] & cobbles [r]	end of archaeological deposits, ending into interface with sterile levels
end	71	70	71	70	71				
Unit 9 E4368, N0241 2584m asl									
0	0	0	2	1	1	10YR 3/1	loamy silt	Some surface loam, large obsidian frags	surface
1	13	9	7	5	7	10YR 3/1	loamy silt	subrounded & subangular volcanic granules [a], pebbles[vc],cobbles [r]	large fragments of low grade obsidian
2	20	18	13	13	18	10YR 3/1	loamy silt	subangular volcanic cobbles [a], pebbles [vc] roots [vc], sub rounded & subangular pumice cobbles [vc] & pebbles [a]	interface of thick quarry deposits, cores more frequent
3	22	24	18	18	18	10YR 2/2	silt	roots [vc], sub rounded & subangular volcanic cobbles [vc] & pebbles [a], obsidian pebbles & cobbles [r]	dense lithic debris
4	27	28	26	25	27	10YR 2/2	silt	subangular, subrounded pebbles [a], cobbles [vc], obsidian fragments [a]	above layers appear to be slumped/ translocated layer stopped at interface with more compacted in-situ layers
5	32	31	29	28	31	10YR 2/2	silt	subangular, subrounded pebbles [a], cobbles [vc], obsidian fragments [a]	compacted, large blades
6	37	39	35	36	37	10YR 2/2	silt	subangular, subrounded pebbles [a], cobbles [vc], obsidian fragments [a]	increasing frequency of small angular debris
7	43	45	41	40	43	10YR 2/2	silt	subangular, subrounded tuff/pumice cobbles [va], pebbles [vc], angular & subangular obsidian fragments [c]	dense lithic surface on west side of unit
8	50	50	46	46	46	10YR 2/2	silt	subangular volcanic pebbles [rare], cobbles[rare]	few artifacts, surface is beginning to show natural hillslope
9	53	53	52	51	52	10YR 3/4	clay-silt	thin roots	very little material, into subsoils
10	58	57	56	56	57	7.5YR 3/4	clay-silt	thin roots, volcanic granules [r]	sterile
11	65	68	68	66	66	7.5YR 3/4	clay-silt		
end	71	73	73	70	72				

Unit 10 E4420, N0203 2587m asl									
Start of level (cm below surface)						Sediment description			
Lvl	NW	NE	SE	SW	C	Munsell	Texture	Inclusions	Notes
1	20	21	19	19	20	10YR 2/1	loamy silt	roots, organics, rounded pebbles [r], mica granules [r]	bulk removal of overburden
2	35	34	37	39	36	7.5YR 2.5/1	silt	subrounded & subangular volcanic [r], mica granules [c],	Large burrow in north wall
3	45	45	48	49	48	7.5YR 2.5/1	silt	angular & subangular volcanics [c], lava cobbles [r]	Large burrow in north wall, several large blades, material more common
4	56	55	53	54	55	10YR 3/2	clay-silt	angular & subangular volcanics [c]	Large burrow in north wall, artifact density decreasing
5	67	70	69	68	70	10YR 3/3	clay-silt	subangular volcanic cobbles [r], volcanic pebbles [c]	moving into sterile subsoils

APPENDIX II: 3D models of common Elmenteitan core types.

Single faced
bi-directional blade core

GsJj50
Core 350.1
N0241 E4368
Level 7

Multiplatform core

Enkapune Ya Muto 12060

Single faced
bladelet core

Gambles Cave II #2

Singe faced
paralell blade core

Enkapune Ya Muto 161-1

Single face
blade core

Gambles Cave II #4

Rotated bladelet core
(adjacent platform)

Ngamuriak #1573

Naviform blade core

Olilpilikunia - 1

APPENDIX III: Supplementary tables and graphs.

Table III-A. Measurements of striking platform sizes at all PN sites included in this analysis.

Site	Platform type	n	Avg. platform width (mm)	Plat. width std. error (mm)	Avg. platform thickness (mm)	Plat. thickness std. error (mm)	Average platform area (mm ²)
Bromhead's	DPF	6	8.11	2.05	3.46	0.69	33.64
Enkapune ya Muto	Plain	4	11.30	2.72	4.35	1.39	59.74
	DPF	25	6.84	0.54	2.82	0.20	21.30
Enkapune ya Sauli	Plain	12	12.42	1.74	4.37	0.74	67.03
	DPF	20	7.99	0.65	2.90	0.16	24.19
Gamble's II	DPF	16	7.45	0.86	3.45	0.67	31.59
Gogo Falls	Plain	3	9.05	4.04	3.56	1.57	44.78
	DPF	7	5.41	0.91	2.44	0.14	13.96
GsJj50	Plain	568	15.73	7.34	6.77	3.47	127.24
	DPF	407	8.18	4.20	3.04	1.51	29.31
Olopilokunya	Plain	6	6.92	2.88	6.28	22.56	40.48
	DPF	13	8.42	1.64	2.72	0.34	28.10
Lion Hill	DPF	5	4.32	0.52	2.16	0.17	9.65
Ngamuriak	Plain	16	13.11	1.82	4.97	0.62	74.74
	DPF	20	9.15	0.70	3.21	0.24	31.03
Remnant	Plain	4	12.56	1.35	4.74	44.73	75.57
	DPF	16	10.88	1.40	4.86	0.76	64.38
Suswa Lava Tubes	DPF	6	7.24	1.25	2.49	0.35	19.96
Wadh Lang'o	Plain	3	9.05	1.31	3.74	0.69	35.53
	DPF	6	6.21	0.75	2.13	0.36	13.52
Narosura	Plain	13	10.41	2.06	5.13	0.79	67.90
	Ground	26	7.11	0.48	3.23	0.29	24.73

Table III-B. Platform preparation and flake scar orientation counts for sampled PN sites.

Site	<u>Platform preparation</u>					<u>Flake scar orientation</u>			
	Plain	DPF	Ground	Faceted	Point	Paralell	Opposed	Alternating	Radial
GsJj50a	56	35	23	8	19	107	13	16	16
GsJj50b	93	36	11	1	15	150	20	12	8
EYS	23	37	9	1	4	70	4	2	0
EYM	5	15	8	1	6	38	1	2	0
Gambles	1	11	5	2	3	21	1	0	0
Remnant	4	14	3	1	6	16	8	2	3
Bromhead's	1	3	0	2	0	7	0	0	0
Lion Hill	1	4	0	2	1	9	1	0	0
Njoro	5	12	1	0	2	23	0	0	0
Suswa	0	6	0	0	0	8	0	0	0
NGA	19	26	6	1	3	43	7	6	0
OLI	6	10	3	0	1	15	4	1	0
Wadh Lango	3	5	1	1	6	15	2	1	0
Gogo Falls	3	5	2	0	5	12	2	1	2
Narosura (SPN)	13	4	26	4	0	28	17	2	0

Table III-C. Measures used to calculate obsidian access values for interpolation map in Figure 8.17.

	Max blade length (mm)	Average blade length (mm)	Blade length standard error	Average platform size (mm2)	Obsidian Access Value
BRM	120.85	86.338	10.1	33.63	13.05944
EYM	102.3	70.63	1.42	27.49	11.09801
GAM	140.08	92.99	4.08	40.52	14.86848
GGF	79.63	48.78	2.93	23.21	8.71535
OLI	83.3	45.3	3.14	30.78	9.14
LNH	92.29	76.7	4.48	14.41	10.15331
NGA	125.43	64.2	4.45	43.01	13.24543
NJR	103.09	59.3	3.57	25.29	10.88653
REM	93.45	61.4	3.02	51.11	10.9397
SUS	136.87	86.9	8.54	19.6	14.07924
WDL	76.69	51.2	3.38	17.1	8.339851
EYS	142.4	46.93	3.13	40.58	14.66505

Figure III-D. Plot of average striking platform widths and thicknesses for Elmenteitan sites (black circles) and Narosura (black triangles). Only platforms with DPF were included for Elmenteitan sites on this plot, Narosura sample is divided between plain (P) and ground (G)

Figure III-E. Scatterplot of platform thickness to blade thickness for blades from Elmenteitan sites (GsJj50 and Narosura not included). Platform thickness is the best predictor for blade thickness ($r^2=.66$, $p<..05$).

Figure III-F. Sampled Pastoral Neolithic sites relative modern land-cover. (white areas=no data). Data from World Resources Institute.

Figure III-G. Sampled Pastoral Neolithic sites relative modern mean annual percipitation. Data from World Resources Institute.

Appendix IV: Lithic illustrations

Figure IV-A: Modified blade segments from GsJj50: (a) abrupt lateral retouch on proximal fragment with languette break; (b,c) burin plân; (d) lateral and inverse retouch; (e) abrupt bi-lateral retouch; (f) denticulated; (g) burin and flat retouch; (h) notched and inverse retouched on languette break; (i) utilized; (j) core-on-flake; (k) lateral and inverse alternated utilization.

Figure IV-B: Platform removal flakes from GsJj50, black arrows denote direction of removal: (a) cresting blade; (b,c,f,i) 90-degree platform removal; (d,e) platform removal from same direction; (g) platform removal from opposed end; (h) removal of platform and stacked step fractures on core.

Figure IV-C: Platform removals oriented at 90 degrees to the platform from GsJ50.

Figure IV-D: Worked pieces from GsJj50: (a-d) bipolar cores; (e) convergent scraper.

APPENDIX V: Research permits and affiliations

THIS IS TO CERTIFY THAT

MR. STEVEN THOMAS GOLDSTEIN of **WASHINGTON UNIVERSITY IN ST. LOUIS, 324 Woodmill Dr., 14626 Rochester NY, USA,** has been permitted to conduct research in **Kakameba County**, **WAKUMBA COUNTY** on the topic: **ECONOMIC ORGANIZATION IN THE PASTORAL NEOLITHIC ARCHAEOLOGICAL INVESTIGATIONS OF THE ELMENTEITAN OBSIDIAN QUARRY ON FEBRUARY KEKEMO** for the period ending: **30th November, 2014.**

Dwight D. Kibuka
Applicant's Signature
NACOSTI National Commission for Science, Technology & Innovation

CONDITIONS:

(1) You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.

(2) Government Officers will not be interviewed without prior appointment.

(3) No questionnaire will be used unless it has been approved.

(4) Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.

(5) You are required to submit at least two(2) hard copies and one(1) soft copy final report.

(6) The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice.

RESEARCH CLEARANCE PERMIT

Serial No. A-8791

CONDITIONS: see back page

NATIONAL MUSEUMS OF KENYA

WHERE HERITAGE LIVES ON

NMK/ESC/ACL/g/VOL.1

17th July, 2015

Steven T. Goldstein, MA
Department of Anthropology,
George Washington University in St. Louis
CB1114 - 1 Brookings Drive
Saint Louis, MO 63130
USA

RE: RESEARCH AFFILIATION

I have received your request seeking renewal of affiliation to the National Museums of Kenya (NMK) in order to analyze material collected from the Elmenteitan Quarry Site (GsJj50) and the stone tool from other pastoral Neolithic sites housed in the museum.

I am pleased to inform you that you have been offered affiliation with the NMK. You will be affiliated to Archaeology Section within Earth Sciences department upon payment of US\$ 200 affiliation fee to the NMK's Accounts Department. This affiliation will be for a period of ONE year (1) from 15th July 2015 to 15th July 2016. During this period, you will be expected to conform to all institutional requirements, use of facilities and collections are concerned. You will also be expected to forward to my office through the Head of the Earth Sciences Department any reports and scientific publication on your present and future activities.

This research affiliation does not exonerate you from abiding to the immigration requirements. NMK shall not be held responsible for blame resulting from failure to fulfill these requirements as per the prevailing international and Kenyan immigration laws.

Yours sincerely,

MZALE N. KIBUNJIA, PHD., EBS
DIRECTOR GENERAL.

CC: Head, Earth Sciences
Head, Archaeology

References Cited

- Aceituno, F. J. & Loaiza, N.
 2014 Early and Middle Holocene evidence for plant use and cultivation in the Middle Cauca River Basin, Cordillera Central (Colombia). *Quaternary Science Reviews* 86:49-62.
- Affolter, J.
 2002 Provenance des silex préhistoriques du Jure et des régions limitrophes. Neuchatel, Service et musée cantonal d'archéologie. *Archéologie Neuchateloise* 28(2):1-335.
- Aktipis, A. C., Cronk, L. and de Aguiar, R. 2011
 2011 Risk-pooling and herd survival: An agent-based model of a Maasai gift-giving system. *Human Ecology* 39:131-140.
- d'Altroy, T. N., Earle, T. K., Browman, D. L., La Lone, D., Moseley, M. E., Murra, J. V., Myers, T. P., Salomon, F., Schreiber, K. J. and Topic, J. R.
 1985 Staple finance, wealth finance, and storage in the Inka political economy [and comments and reply]. *Current Anthropology* 26(2):187-206.
- Aldenderfer, M. S.
 2001 Andean pastoral origins and evolution: the role of ethnoarchaeology. In *Ethnoarchaeology of South America: Contributions to archaeological method and theory*, edited by L. A. Kunz, pp. 19-30. Ann Arbor: International Monographs in Prehistory.
- Ambrose, S. H.
 1980 Elmenteitan and other late Pastoral Neolithic adaptations in the central highlands of East Africa. In *Proceedings of the Eighth Panafrikan Congress of Prehistory and Quaternary Studies*, Nairobi, edited by R. E. Leakey and B. A. Ogot, pp. 279-282. Nairobi: The Louis Leakey Memorial Institute for African Prehistory.
- 1982 Archaeology and linguistic reconstructions of history in East Africa. In *The archaeological and linguistic reconstructions of African history*, edited by C. Ehret and M. Posnansky, pp. 104-157. Berkeley: University of California Press.
- 1984a The introduction of pastoral adaptations to the highlands of East Africa, In *From hunters to farmers: The causes and consequences of food production in Africa*, edited by J. D. Clark and S. A. Brandt, pp. 212- 239. Berkeley: University of California Press.
- 1984b Excavations at Deloraine, Rongai, 1978. *Azania* 20:29-67.
- 1984c *Holocene environments and human adaptations in the Central Rift Valley, Kenya*. Ph.D. Dissertation, University of California, Berkeley.
- 1998 Chronology of the Later Stone Age and food production in East Africa. *Journal of Archaeological Science* 25(4):377-392.

- 2001 East African Neolithic. In *Encyclopedia of prehistory Volume 1: Africa*, edited by P. N. Peregrine and M. Ember, pp. 97-109. New York: Kluwer Academic/Plenum.
- 2002 Small things remembered: origins of early microlithic industries in sub-Saharan Africa. *Archaeological papers of the American Anthropological Association* 12(1):9-29.
- 2012 Obsidian hydration dating and source exploitation studies in Africa. In *The dating and provenance of obsidian and ancient manufactured glasses*, edited by I. Liritzis and C. M. Stevenson, pp. 56-72. Albuquerque: University of New Mexico Press.
- Ambrose, S. H. and DeNiro, M. J.
 1986a Reconstruction of African human diet using bone collagen carbon and nitrogen isotope ratios. *Nature* 319:321-24.
 1986b The isotopic ecology of East African mammals. *Oecologia*, 69(3):395-406.
- Ambrose, S. H. and Sikes, N. E.
 1991 Soil carbon isotope evidence for Holocene habitat change in the Kenya Rift Valley. *Science* 253(5026):1402.
- Amin, M., Willets, D., and Eames, J.
 1987 *The last of the Maasai*. New York: Random House.
- Ammerman, A. J. and Andrefsky Jr, W.
 1982 Reduction sequences and the exchange of obsidian in Neolithic Calabria. In *Contexts for prehistoric exchange*, edited by J. E. Ericson and T. K. Earle, pp. 149-172. New York: Academic Press.
- Andrefsky Jr, W.
 1991 Inferring trends in prehistoric settlement behavior from lithic production technology in the southern plains. *North American Archaeologist* 12(2):129-144.
 1994a The geological occurrence of lithic material and stone tool production strategies. *Geoarchaeology* 9(5):375-391.
 1994b Raw-material availability and the organization of technology. *American Antiquity* 59(1):21-34.
 2004 Raw-material availability and the organization of lithic technology. *American Antiquity* 59(1):21-34.
 2005 *Lithics: Macroscopic Approaches to Lithic Analysis* 2nd Edition. Cambridge: Cambridge University Press.
 2010 The analysis of stone tool procurement, production, and maintenance. *Journal of Archaeological Research* 17:65-103.

- Andrews, B.
2003 Measuring prehistoric craftsman skill: contemplating its application to Mesoamerican core-blade research. In *Mesoamerican lithic technology: Experimentation and Interpretation* in K. Hirth, pp.208-219. Salt Lake City: University of Utah Press.
- Angelbeck, B.
2016 The balance of autonomy and alliance in anarchic societies: The organization of defenses in the Coast Salish past. *World Archaeology* 48(1):51-69.
- Apel, J.
2008 Knowledge, know-how and raw material-the production of Late Neolithic flint daggers in Scandinavia. *Journal of Archaeological Method and Theory* 15(1):91-111.
- Arbuckle, B.S.
2012 Animals and inequality in Chalcolithic central Anatolia. *Journal of Anthropological Archaeology* 31(3):302-313.
- Arkell, A. J.
1949 *Early Khartoum*. Oxford: Oxford University Press.
- Arnold, J. E.
1987 *Craft specialization in the prehistoric Channel Islands, California* (Vol. 18). Berkeley: University of California Press.

1990 Lithic resource control and economic change in the Santa Barbara Channel region. *Journal of California and Great Basin Anthropology* 12(2):158-172.

1992 Complex hunter-gatherer-fishers of prehistoric California: Chiefs, specialists, and maritime adaptations of the Channel Islands. *American Antiquity* 57(1):60-84.
- Arnold III, P. J.
1991 Dimensional standardization and production scale in Mesoamerican ceramics. *Latin American Antiquity* 2(4):363-370.
- Ashley, C. Z. and Grillo, K. M.
2015 Archeological ceramics from eastern Africa: past approaches and future directions. *Azania* 50(4):460-80.
- Ashley, G. M., Ndiema, E. K., Spencer, J. Q., Harris, J. W. and Kiura, P. W.
2011 Paleoenvironmental context of archaeological sites, implications for subsistence strategies under Holocene climate change, northern Kenya. *Geoarchaeology* 26(6):809-837.

- Balasse, M., Smith, A. B., Ambrose, S. H. and Leigh, S. R.
2003. Determining sheep birth seasonality by analysis of tooth enamel oxygen isotope ratios: the Late Stone Age site of Kasteelberg (South Africa). *Journal of Archaeological Science* 30(2): 205-215.
- Balasse M., and Ambrose S. H.
2005 Mobilité altitudinale des pasteurs néolithiques dans la vallée du Rift (Kenya): Premiers indices de l'analyse du $\delta^{13}\text{C}$ de l'émail dentaire du cheptel domestique. *Anthropozoologica* 40(1):147–166.
- Bamforth, D. B.
1986 Technological efficiency and tool curation. *American Antiquity* 51(1):38-50.

1990 Settlement, raw material, and lithic procurement in the central Mojave Desert. *Journal of Anthropological Archaeology* 9(1):70-104.

1991 Technological organization and hunter-gatherer land use: A California example. *American Antiquity* 56:216-234.
- Bamforth, D. B. and Bleed, P.
1997 Technology, flaked stone technology, and Risk. *Archaeological Papers of the American Anthropological Association* 7(1):109-139.
- Bamforth, D. B. and Finlay, N.
2008 Introduction: archaeological approaches to lithic production skill and craft learning. *Journal of Archaeological Method and Theory* 15(1):1-27.
- Bar-Yosef, O.
1998 On the Nature of Transitions: the Middle to Upper Palaeolithic and the Neolithic Revolution. *Cambridge Archaeological Journal* 8(2):141-163.
- Barich, B. E.
2002 Cultural responses to climatic change in North Africa: the beginning and spread of pastoralism in the Sahara. In *Droughts, Flood, and Culture*, edited by F. Hassan, pp. 209-223. London: Springer.
- Barton, M. C., Olszewski, D. I., and Coinman, N. R.
1996 Beyond the graver: Reconsidering burin function. *Journal of Field Archaeology* 23:111-125.
- Baumler, M.
1988 Core reduction, flake production, and the Middle Paleolithic industry of Zobiste (Yugoslavia). In *Upper Pleistocene Prehistory of Western Eurasia*, edited by H. L. Dibble and A. Montet-White, pp. 255-274. Philadelphia: University Museum, University of Pennsylvania.

- Bayman, J. M.
2010 The precarious “middle ground”: Exchange and the reconfiguration of social identity in the Hawaiian kingdom. In *Trade and exchange*, C. D. Dillian and C. L. White, pp. 129-148. New York: Springer.
- Beck, C., Taylor, A. K., Jones, G. T., Fadem, C. M., Cook, C. R., & Millward, S. A.
2002 Rocks are heavy: transport costs and Paleoarchaic quarry behavior in the Great Basin. *Journal of Anthropological Archaeology* 21(4):481-507.
- Behnke, R.
1995 Natural resource management in pastoral Africa. In *Social Aspects of Sustainable Dryland Management*, edited D. Stiles, pp. 145–152. West Sussex, UK: Wiley.
- Behnke, R. and Scoones, I.
1992 *Rethinking range ecology: implications for rangeland management in Africa*. London: IIED 43p. En IIED Dryland Networks Programme Issues Paper (33).
- Bernsten, J. L.
1976 The Maasai and their neighbors: Variables of Interaction. *African Economic History* 2:1-11.
- Bettinger, R. L.
1982 Aboriginal exchange and territoriality in Owens Valley, California. In *Contexts of prehistoric exchange*, edited by J. E. Ericson and T. K. Earle, pp. 103-128. New York: Academic Press.
- Biagetti, S.
2014 *Ethnoarchaeology of the Kel Tadrat Taureg: Pastoralism and Resilience in Central Sahara*. New York: Springer.
- Binford, L. R.
1973 Interassemblage variability: The Mousterian and the “functional” argument. In *The Explanation of Cultural Change*, edited by C. Renfrew, pp. 227-254. London: Duckworth.
- 1977 Forty-seven Trips. In *Stone Tools as Cultural Markers*, edited by R.V. S. Wright, pp. 24-36. Canberra: Australian Institute of Aboriginal Studies.
- 1979 Organization and formation processes: Looking at curated technologies. *Journal of Anthropological Research* 25:255-273.
- 2001 *Constructing frames of reference: an analytical method for archaeological theory building using ethnographic and environmental data sets*. Berkeley: University of California Press.

- Binford, L. R., and O'Connell, J. F.
1984 An Alyawara day: The stone quarry. *Journal of Anthropological Research* 40:400-432.
- Blackburn, R.
1982 In the land of milk and honey: Okiek adaptations to their forest and neighbors. In *Politics and History in Band Societies*, edited by E. Leacock and R. Lee, pp283-306. Cambridge: Cambridge University Press.
- Blades, B.
1999 Aurignacian lithic economy and early modern human mobility: new perspectives from classic sites in the Vézère Valley of France. *Journal of Human Evolution* 37(1):91-120.
- Bleed P.
1986 The optimal design of hunting weapons: Maintainability or reliability. *American Antiquity* 51(4):737-747.

2008 Skill matters. *Journal of Archaeological Method and Theory* 15(1):154-166.
- Bleed, P. and Bleed, A.
1987 Energetic efficiency and hand tool design: a performance comparison of push and pull stroke saws. *Journal of Anthropological Archaeology* 6(2):189-197.
- Blegen, N.
2017 The earliest long-distance obsidian transport: Evidence from the ~200 ka Middle Stone Age Sibilo School Road Site, Baringo, Kenya. *Journal of Human Evolution* 103:1-19. <http://dx.doi.org/10.1016/j.jhevol.2016.11.002>
- Bloxom, E.
2011 Ancient quarries in mind: pathways to a more accessible significance. *World Archaeology* 43(2):149-166.
- Bodu, P., Karlin, C., and Ploux, S.
1990 Who's who? The Magdalenian flintknappers of Pincevent (France). In E. Ciesla, S. Eickhoff, N. Arts and D. Winther (Eds.), *The Big Puzzle. International Symposium on Refitting Stone Artefacts, Mon Repos 1987*. Bonn: Holos.
- Boivin, N. L., Zeder, M. A., Fuller, D. Q., Crowther, A., Larson, G., Erlandson, J. M., Denham, T. and Petraglia, M. D.
2016 Ecological consequences of human niche construction: Examining long-term anthropogenic shaping of global species distributions. *Proceedings of the National Academy of Sciences* 113(23):6388-6396.

- Bollig, M.
2000 Unmaking a market: The encapsulation of a regional trade network. Northwest Namibia between the 1860s and 1950s. In *Frühe kolonialgeschichte Namibias 1880-1930*, edited by W. J. G Möhlig and M. Bollig, pp. 11-29. Berlin: Rüdiger Köppe.
- Bonnefille, R. and Mohammed, U.
1994 Pollen-inferred climatic fluctuations in Ethiopia during the last 3000 years. *Palaeogeography, Palaeoclimatology, Palaeoecology* 109(2-4):331-343.
- Borgerhoff Mulder, M., Fazzio, I., Irons, W., McElreath, R.L., Bowles, S., Bell, A., Hertz, T. and Hazzah, L.
2010 Pastoralism and wealth inequality: revisiting an old question. *Current Anthropology* 51(1):35-48.
- Bourdieu, P.
1977 *Outline of a Theory of Practice*. Cambridge: Cambridge University Press.
- Boyd, R., Richerson, P.J.
1985 *Culture and the Evolutionary Process*. London: University of Chicago Press.
- Bower, J. R.
1991 The Pastoral Neolithic of East Africa. *Journal of World Prehistory* 5:49-82.
- Bower, J. R., and Nelson, C. M.
1978 Early pottery and pastoral cultures of the Central Rift Valley, Kenya. *Man* 13:554-566.
- Bower, J. R., Nelson, C. M., Waibel, A.F., and Wandibba, S.
1977 The University of Massachusetts' Later Stone Age/Pastoral "Neolithic" comparative study in Central Kenya: An overview. *Azania* 12(1):19-45.
- Bradley, R.
2004 Domestication, Sedentism, Property and Time: Materiality and the Beginnings of Agriculture in Northern Europe. In *Rethinking Materiality: The Engagement of Mind with the Material World*, edited by E. DeMarrais, C. Gosden and C. Renfrew, pp. 107-115. Cambridge: McDonald Institute for Archaeological Research.
- Bradley, R. J.
1992 *Nomads in the Archaeological Record: Case Studies in the Northern Provinces of the Sudan*. Meroitica 13. Berlin: Akademie Verlag.
- Brandt, S. A.
1984 New perspectives on the origins of food production in Ethiopia. In *From hunters to farmers: the case and consequences of food production in Africa*, edited by J. D. Clark and S. Brandt, 173-190. Berkeley: University of California Press.

- Brandt, S. A. and Carder, N.
1987 Pastoral rock art in the Horn of Africa: Making sense of udder chaos. *World Archaeology* 19(2):194-213.
- Brass, M. J.
2016 Reinterpreting chronology and society at the mortuary complex of Jebel Moya (Sudan). Ph.D dissertation, UCL (University College London).
- Bretzke, K. and Conard, N. J.
2012 Evaluating morphological variability in lithic assemblages using 3D models of stone artifacts. *Journal of Archaeological Science* 30:2741-49.
- Brézillion, M. N.
1968 *La denomination des objets de pierre taillée: Matériaux pour un vocabulaire des préhistoriens de langue française*. Paris: Éditions du centre national de la recherche scientifique 15.
- Bril, B., Roux, V. and Dietrich, G.
2005 Stone knapping: Khambhat (India), a unique opportunity?. Stone knapping: The necessary conditions for a uniquely hominin behavior. In *Stone knapping: The necessary conditions for a uniquely hominin behavior*, edited by B. Bril and V. Roux, pp.53-72. Cambridge: McDonald Institute Monograph Series.
- Bronk Ramsey, C.
2009 Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1):337-360.

2015 Oxcal radiocarbon calibration program, version 4.2.
<https://c14.arch.ox.ac.uk/oxcal/OxCal.html>.
- Browman, D. L.
1990 Camelid pastoralism in the Andes: Llama caravan fleteros, and their importance in production and distribution. In *Nomads in a changing world*, edited by P. C. Salzman and J. G. Galaty, pp. 395-438. Naples: Instituto Universitario Orientale.

2008 Pastoral nomadism in the Central Andes: a historic retrospective example. In *The archaeology of mobility: Old World and New World nomadism*, edited by H. Barnard and W. Wendrich, pp. 160-173. Cotsen Institute of Archaeology, University of California, Los Angeles.
- Brown, J. A.
1995 On mortuary analysis—with special reference to the Saxe-Binford research program. In *Regional approaches to mortuary analysis*, pp. 3-26. New York: Springer
- Brown, F. H., Nash, B. P., Fernandez, D. P., Merrick, H. V. and Thomas, R. J.
2013 Geochemical composition of source obsidians from Kenya. *Journal of Archaeological Science* 40(8):3233-3251.

- Brumfiel, E.M.
1992 Distinguished lecture in archeology: Breaking and entering the ecosystem—gender, class, and faction steal the show. *American Anthropologist* 94(3):551-567.
- Bryan, K.
1950 *Flint Quarries-the Sources of Tools and, at the same time, the Factories of the American Indian*. Papers of the Peabody Museum of Archaeology and Ethnology 1. Cambridge: Harvard University Press.
- Bunn, H. T.
1983 Comparative analysis of modern bone assemblages from a San hunter-gatherer camp in the Kalahari Desert, Botswana, and from a spotted hyena den near Nairobi, Kenya. In *Animals and Archaeology 1: Hunters and their Prey*, edited by J. Clutton-Brock and C. Grigson, pp.143-148. Oxford: BAR International Series 163.
- Cann, J. R.
1983 Petrology of obsidian artefacts. In *The petrology of archaeological artefacts*, edited by D. R. Kempe and A. P. Harvey, pp. 227-255. London: Clarendon press.
- Capriles, J.
2011 *The economic organization of early camelid pastoralism in the Andean highlands*. Ph.D. dissertation, Washington University in St. Louis.
- Carr, P. J.
1994 *The organization of North American prehistoric chipped stone tool technologies*. Archaeological Series 7. Ann Arbor: International Monographs in Prehistory.
- Catley, A., Lind, J., and Scoones, I.
2012 *Pastoralism and development in Africa*. New York: Routledge.
- Cavalli-Sforza, L. L. and Feldman, M. W. (Eds.)
1981 *Cultural transmission and evolution: a quantitative approach* (No. 16). Princeton: Princeton University Press.
- Cervicek, P. and Kortler, F.
1979 Rock art discoveries in the northern Yemen. *Paideuma* 25:225-250.
- Chapman, C. A. and Chapman, L. J.
1996 Mid-elevation forests: A history of disturbance and regeneration. In *East African ecosystems and their conservation*, edited by T. R. McClanahan and T. P. Young, pp. 385-400. New York: Oxford University Press.
- Childe, V.G.
1957 *Civilizations, cities, and towns*. Cambridge: Cambridge University Press.

- Chritz, K. L., Marshall, F. B., Zagal, M. E., Kirera, F., & Cerling, T. E.
2015 Environments and trypanosomiasis risks for early herders in the later Holocene of the Lake Victoria basin, Kenya. *Proceedings of the National Academy of Sciences* 112(12):3674-3679.
- Clark, G.
2003 Indigenous transfer of La Pérouse artefacts in the southeast Solomon Islands. *Australian Archaeology* 57(1):103-111.
- Clark, J. D.
1970 *Prehistory of Africa*. Southampton: Thames and Hudson.
1988 The Middle Stone Age of East Africa and the beginnings of regional identity. *Journal of World Prehistory* 2(3):236-305.
- Clark, J. E.
1987 Politics, prismatic blades, and Mesoamerican Civilization. In *The Organization of Core Technology*, edited by J. K. Jonhson and C. A. Morrow, pp. 259-284. Boulder: Westview Press.

2003 Craftsmanship and Craft Specialization. In *Mesoamerican Lithic Technology: Experimentation and Interpretation*, edited by K. G. Hirth, pp. 220-233. Salt Lake City: The University of Utah Press,
- Clarke, M. C. G., Woodhall, D. G., Allen, D., Darling, G.
1990. *Geological, Volcanological and Hydrological Controls on the Occurrence of Geothermal Activity in the Area Surrounding Lake Naivasha, Kenya*. Republic of Kenya, Ministry of Energy, Nottingham: Derry and Sons Ltd.
- Clarke, R.
1935 The flint knapping industry at Brandon. *Antiquity* 9(31):38-56.
- Clarkson, C., Vinicius, L. and Lahr, M. M.
2006 Quantifying flake scar patterning on cores using 3D recording techniques. *Journal of Archaeological Science* 33(1):132-142.
- Cleghorn, P. L.
1986 Organizational structure at the Mauna Kea adze quarry complex, Hawaii. *Journal of Archaeological Science* 13(4):375-387.
- Clist, B.
1987 A critical reappraisal of the chronological framework of the Urewe Early Iron Age industry. *Muntu* 6:35-62.
- Close, A.
1990 Living on the edge: Neolithic herders in the eastern Sahara. *Antiquity* 64: 79-96.

- Coburn, Thomas B.
1995 Climbing the Mountain of God. *J Am Acad Relig* LXIII (1):127-140.
- Collett, D. and Robertshaw P. T.
1983 Pottery traditions of early pastoral communities in Kenya. *Azania* 18(1):107-125.
- Conard, N. J.
2010 Cultural modernity: Consensus or conundrum? *Proceedings of the National Academy of Science* 107(17):7621-22.
- Conard, N. J., Soressi, M., Parkington, J. E., Wurz, S., & Yates, R.
2004 A unified lithic taxonomy based on patterns of core reduction. *South African Archaeological Bulletin* 59(179):12-16.
- Conkey, M. W.
1991 Contexts of action, contexts for power: material culture and gender in the Magdalenian. In *Engendering Archaeology: Women and Prehistory*, edited by M. W. Conkey and J. M. Gero, pp.57-92. Oxford: Blackwell.
- Contreras, D. A. and Tripcevich, N.
2012 Archaeological approaches to obsidian quarries: Investigations at the Quispisisa source. In *Mining and quarrying in the ancient Andes*, edited by N. Tripcevich and K. J. Vaughn, pp. 23-44. New York: Springer.
- Costin, C. L. and Hagstrum, M. B.
1995 Standardization, labor investment, skill, and the organization of ceramic production in late prehispanic highland Peru. *American Antiquity* 60(4):619-639.
- Cowan, F. L.
1999 Making sense of flake scatters: lithic technological strategies and mobility. *American Antiquity* 64(4):593-607.
- Cowgill, G. L.
2004 Origins and development of urbanism: archaeological perspectives. *Annual Review of Anthropology* 33:525-549.
- Crabtree, D. E.
1972 *An Introduction to Flintworking*. Occasional Papers of the Museum of Idaho State University 28. Pocatello, ID: Museum of Idaho State University.
- Cronk, L.
1989 From Hunters to Herders: Subsistence Change as Reproductive strategy among the Mukogodo. *Current Anthropology* 30(2):224-234.

- Crumley, C. L.
1987 A dialectical critique of hierarchy. In *Power relations and state formation* edited by T. C Patterson and C. W. Gailey, pp. 403-429. San Diego: Academic Press.
- Dahl, G. and Hjort, A.
1976 *Having herds: Pastoral herd growth and household economy*. Stockholm studies in social anthropology. Stockholm: Liber Tryck.
- Dale, D. D. and Ashley, C. Z.
2010 Holocene hunter-fisher-gatherer communities: new perspectives on Kansyore using communities of Western Kenya. *Azania* 45:24-48.
- Dale, D.D., Marshall, F. B. and Pilgram, T.
2004. Delayed-return hunter-gatherers in Africa? Historic perspectives from the Okiek and archaeological perspectives from the Kansyore. In *Hunters and gatherers in theory and archaeology* edited by G. M. Crothers, pp.340-75. Carbondale: SIU/Center for Archaeological Investigations.
- Dalton, G.
1969 Theoretical issues in economic anthropology. *Current Anthropology* 10:63-102.
- Darras, V.
1994 Les mines-ateliers d'obsidienne de la région de Zinaparo-Prieto, Michoacan, Mexique. *Bulletin de la Société préhistorique française* 91(4):290-301.
- Davies, J.
2008 Turning the tide: Enabling sustainable development for Africa's mobile pastoralists. *Natural Resources Forum* 32(3):175-184.
- De Cort, G., Bessems, I., Keppens, E., Mees, F., Cummings, B., & Vershuren, D.
2013 Late-Holocene and recent hydroclimate variability in the central Kenya Rift Valley: The sediment record of hypersaline lakes Bogoria, Nakuru, and Elmenteita. *Paleogeography, Paleoclimatology, Paleoecology* 388(15):69-80.
- Denbow, J. R.
1984 Prehistoric herders and foragers of the Kalahari: The evidence for 1500 years of interaction. In *Past and Present in Hunter-Gatherer Studies*, edited by C. Schrire, pp. 175-193. Walnut Creek: Left Coast Press.
- Di Lernia, S.
2002 Dry climatic events and cultural trajectories: adjusting Middle Holocene pastoral economy of the Libyan Sahara. In *Droughts, food, and culture*, edited by F. Hassan, pp. 225-250. London: Springer

- Dibble, H. L., & Pelcin, A.
1995 The effect of hammer mass and velocity on flake mass. *Journal of Archaeological Science* 22(3):429-439.
- Dillian, C. D.
2002 *More than toolstone: differential utilization of Glass Mountain obsidian*. Doctoral Dissertation. Berkeley: University of California, Berkeley.

2007 Archaeology of fire and glass: Cultural adoption of Glass Mountain Obsidian. In *Living under the Shadow: Cultural Impacts of Volcanic Eruptions*, edited by J. Grattan and R. Torrence, pp. 253-273. Walnut Creek: Left Coast Press.
- Dillian, C. D., & White, C. L.
2010 Introduction: Perspectives on trade and exchange. In *Trade and Exchange*, edited by D. Dillian and C. L. White, pp. 3-14. New York: Springer.
- Dillian, C. D., Bello, C. A. and Shackley, M. S.
2007 Crossing the Delaware: documenting super-long distance obsidian exchange in the mid-Atlantic. *Archaeology of Eastern North America* (35):93-104.
- Dobres, M.A. and Hoffman, C.R.
1994 Social agency and the dynamics of prehistoric technology. *Journal of Archaeological Method and Theory* 1(3):211-258.
- Dombrowski, K.
1993 Some considerations for the understanding of small herd dynamics in East African arid zones: The long term consequences of bridewealth exchange networks. *Human Ecology* 21:23-50.
- Duke, H. and Pargeter, J.
2015 Weaving simple solutions to complex problems: an experimental study of skill in bipolar cobble-splitting. *Lithic Technology* 40(4):349-365.
- Dunne, J., Evershed, R.P., Salque, M., Cramp, L., Bruni, S., Ryan, K., Biagetti, S. and di Lernia, S.
2012 First dairying in green Saharan Africa in the fifth millennium BC. *Nature* 486(7403): 390-394.
- Dunne, J., Mercuri A. M., Evershed, R. P., Bruni, S., and di Lernia, S.
2017 Earliest direct evidence of plant processing in prehistoric Saharan pottery. *Nature Plants* 3:16194.
- Dyson-Hudson, R. and Dyson-Hudson, N.
1980 Nomadic pastoralism. *Annual Review of Anthropology* 9:15-61.

- Dyson-Hudson, R. and Smith, E.A.
1978 Human territoriality: an ecological reassessment. *American Anthropologist* 80(1):21-41.
- Earle, T. K.
1982 Prehistoric economics and the archaeology of exchange. *Contexts for prehistoric exchange*. In *Contexts for prehistoric exchange*, edited by J. E. Ericson and T. K. Earle, pp. 1-12. New York: Academic Press.
- Earle, T. K. and Ericson, J. E.
1977 Exchange systems in archaeological perspective. In *Exchange Systems in Prehistory*, edited by T. K. Earle and J. E. Ericson, pp. 3-12. New York: Academic Press.
- Eerkens, J. W.
2000 Practice Makes Within 5% of Perfect: Visual Perception, Motor Skills, and Memory in Artifact Variation. *Current Anthropology* 41(4):663-668.
- Eerkens, J. W. and Bettinger, R. L.
2001 Techniques for assessing standardization in artifact assemblages: Can we scale material variability? *American Antiquity* 66(3):493-504.
- Ehret, C.
1974 *Ethiopians and East Africans: The problem of contacts*. Nairobi: East African Publishing House.

1980 *The historical reconstruction of Southern Cushitic phonology and vocabulary (Vol. 5)*. Berlin: Reimer.

2001 Establishment of iron-working in eastern, central, and southern Africa: Linguistic inferences on technological history. *Sprache und Geschichte in Afrika* 16:125-175.
- Emerton, Lucy.
1996 Maasai Livelihoods, Forest Use Values and Conservation in Oldonyo Orok, Kenya. *Applied Conservation Economics Discussion Paper* 2, 1-10. Nairobi: African Wildlife Foundation
- Eren, M. I. and Prendergast, M. E.
2008 Comparing and synthesizing unifacial stone tool reduction indices. In *Lithic Technology: Measures of Production, Use, and Curation*, edited by W. Andrefsky Jr. , pp. 49-85. Cambridge: Cambridge University Press.
- Eren, M. I., Greenspan, A. and Sampson, C. G.
2008 Are Upper Paleolithic blade cores more productive than Middle Paleolithic discoidal cores? A replication experiment. *Journal of Human Evolution* 55(6):952-961.

- Eren, M. I., Buchanan, B. and O'Brien, M. J.
2015 Social learning and technological evolution during the Clovis colonization of the New World. *Journal of Human Evolution* 80:159-170.
- Eren, M. I., Lycett, S. J., Roos, C. I. and Sampson, C. G.
2011 Toolstone constraints on knapping skill: Levallois reduction with two different raw materials. *Journal of Archaeological Science*, 38(10):2731-2739.
- Ericson, J. E.
1981 *Exchange and production systems in Californian prehistory*. London: British Archaeological Reports, International Series 110.

1984 Toward the analysis of lithic production systems. In *Prehistoric quarries and lithic production*, edited by J. E. Ericson, and B. A. Purdy, pp. 2-9. Cambridge: Cambridge University Press.
- Ericson, J. E., & Baugh, T. G.
1994 Systematics of the study of prehistoric regional exchange in North America. In *Prehistoric Exchange Systems in North America*, edited by T. G. Baugh and J. E. Ericson, pp. 3-15. New York: Springer.
- Ericson, J. E., & Goldstein, R.
1980 Work space: a new approach to the analysis of energy expenditure. *Anthropology UCLA* 10-11:21-30.
- d'Errico, F.
2003 The invisible frontier. A multi species model for the origin of behavioral modernity. *Evolutionary Anthropology: Issues, News, and Reviews* 12(3):188-202.
- d'Errico, F. and Banks, W. E.
2015 The archaeology of teaching: a conceptual framework. *Cambridge Archaeological Journal* 25(4):859-866.
- Evans-Pritchard, E. E.
1940. *The Nuer*. Oxford: Clarendon.
- Food and Agriculture Organization, United Nations
2015 *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B.D. Scherf & D. Pilling. FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome (available at <http://www.fao.org/3/a-i4787e/index.html>).
- Ferguson, J. R.
2003 An experimental test of the conservation of raw material in flintknapping skill acquisition. *Lithic Technology* 28(2):113-131.

- 2008 The when, where, and how of novices in craft production. *Journal of Archaeological Method and Theory* 15(1):51-67.
- Finlay, N.
 1997 Kid knapping: the missing children in lithic analysis. In *Invisible people and processes: Writing gender and childhood into European archaeology*, edited by J. Moore and E. Scott, pp.203-212. Leicester: Leicester University Press.
- 2008 Blank concerns: issues of skill and consistency in the replication of Scottish Later Mesolithic blades. *Journal of Archaeological Method and Theory* 15(1):68-90.
- Fish, S. K. and Kowalewski, S. A.
 1990 *The archaeology of regions: A case for full-coverage survey*. Washington, DC: Smithsonian Institution Press.
- Fleischer, R. L., Price, P. B., R. M. Walter, and L. S. B. Leakey
 1965 Fission track dating of a Neolithic knife. *Nature* 205:1138.
- Flenniken, J. J.
 1978 Reevaluation of the Lindenmeier Folsom: a replication experiment in lithic technology. *American Antiquity* 43(3):473-480.
- Frachetti, M. D.
 2009 *Pastoralist landscapes and social interaction in Bronze Age Eurasia*. Berkeley: University of California Press.
- 2012 Multiregional emergence of mobile pastoralism and nonuniform institutional complexity across Eurasia. *Current Anthropology* 53:2-38.
- Frahm, E., Goldstein, S. T., and Tryon, C. A.
 2017 Late Holocene forager-fisher and pastoralist interactions along the Lake Victoria shores, Kenya: Perspectives from portable XRF of obsidian artifacts. *Journal of Archaeological Science: Reports* DOI: 10.1016/j.jasrep.2017.01.001
- Fratkin, E.
 1986 Stability and resilience in East African pastoralism: the Rendille and the Ariaal of northern Kenya. *Human Ecology* 14(3):269-286.
- 1998 *Ariaal pastoralists of Kenya: surviving drought and development in Africa's arid lands*. Needham Heights, MAL: Allyn & Bacon Inc.
- 2001 East African pastoralism in transition: Maasai, Boran, and Rendille cases. *African Studies Review* 34:1-25.

- Fry, R. E.
1980 Models of exchange for major shape classes of lowland Maya pottery. *Models and Methods in Regional Exchange*, Society for American Archaeology Papers 1.
- Gallagher, J. P.
1977 Contemporary stone tools in Ethiopia: implications for archaeology. *Journal of Field Archaeology* 4(4):407- 414.
- Galaty, J. G.
1982 Being" Maasai"; being" people-of-cattle": Ethnic shifters in East Africa. *American Ethnologist* 9(1):1-20.
- Galvin, K. A.
2010 Ecology of African Pastoralist societies. *African Journal of Range and Forage Science* 27(2):115-116.
- Gamble, C.
1986 *The Paleolithic Settlement of Europe*. Cambridge: Cambridge University Press.
- Garcea, E. A. A.
2004 An alternative way toward food production: the perspective from the Libyan Sahara. *Journal of World Prehistory* 18(2):107-154.

2013 The archaeological significance of Gobero. In Gobero: *The no-return frontier: archaeology and landscape at the Saharo-Sahelian borderland*. Edited by E. A. A. Garcea, pp. 5-15. Frankfurt: Africa Magna Verlag.
- Garcin, Y., Melnick, D., Strecker, M. R., Olago, D., & Tiercelin, J. J.
2012 East African mid-Holocene wet–dry transition recorded in palaeo-shorelines of Lake Turkana, northern Kenya Rift. *Earth and Planetary Science Letters* 331:322-334.
- Gasse, F.
2000 Hydrological changes in the African tropics since the Last Glacial Maximum. *Quaternary Science Reviews* 19(1):189-211.
- Gautier, A.
1987 Prehistoric men and cattle in North Africa: A dearth of data and a surfeit of models. In *Prehistory of Arid North Africa*, edited by A. Close, pp.163-187. Dallas: Southern Methodist University Press.
- Geertz, H.
1961 *The Javanese family: A study of kinship and socialization* . New York: Free Press of Glencoe.

- Geneste, J. M.
1985 *Analyse lithique d'industries moustériennes du Périgord: une approche technologique du comportement des groupes humains au Paléolithique moyen*. PhD Dissertation, University of Bordeaux.
- Gero J. M.
1989 Assessing social information in material objects: how well do lithics measure up? In *Time, Energy and Stone Tools*, edited by R. Torrence, pp 92-105. Cambridge: Cambridge University Press.
- Giddens, A.
1979 *Central problems in social theory: Action, structure, and contradiction in social analysis* (Vol. 241). Berkeley: University of California Press.
- Gifford, D. P., Isaac, G. L., & Nelson, C. M.
1980 Evidence for predation and pastoralism at Prolonged Drift: A Pastoral Neolithic site in Kenya. *Azania* 15(1):57-108.
- Gifford-Gonzalez, D. P.
1985 Faunal assemblages from Masai Gorge rockshelter and Marula-rockshelter. *Azania* 20(1):69-88.

1998a Early pastoralists in East Africa: Ecological and social dimensions. *Journal of Anthropological Archaeology* 17:166-200.

1998b Gender and Early Pastoralists in East Africa. In *Gender in African Prehistory*, edited by S. Kenya, pp. 115-138. London: AltaMira Press.

2000 Animal disease challenges to the emergence of pastoralism in sub-Saharan Africa. *African Archaeological Review* 17(3):95-139.

2005 Pastoralism and its Consequences. In *African archaeology: A critical introduction* edited by A. Stahl, pp. 187-224. Cambridge: Blackwell.

2015 "Animal disease challenges" fifteen years later: The hypothesis in light of new data. *Quaternary International*, <http://dx.doi.org/10.1016/j.quaint.2015.10.054>.
- Gillespie, R., Hedges, R. E. and Wand, J. O.
1984 Radiocarbon dating of bone by accelerator mass spectrometry. *Journal of Archaeological Science* 11(2):165-170.
- Gillespie, S. D.
2001 Personhood, agency, and mortuary ritual: A case study from the ancient Maya. *Journal of Anthropological Archaeology* 20(1):73-112.

- Gilreath, A.
1984 Stages of Bifacial Manufacture: Learning from Experiments. Paper presented at the 49th Annual Meeting of the Society for American Archaeology, Portland, Oregon.
- Glascock, M.D., Speakman, R.J. and Burger, R.L.
2007 Sources of archaeological obsidian in Peru: descriptions and geochemistry. In *Archaeological chemistry: analytical techniques and archaeological interpretation*. ACS Symposium Series (No. 968, pp. 522-552).
- Glassman, J.
1995 *Feasts and riot: revelry, rebellion, and popular consciousness on the Swahili Coast 1865-1888*. Portsmouth, N.H.: Heinemann.
- Glover, P.E., Glover, E.C., Trump, C., and Wateridge, L.E.D.
1964 The lava caves of Mt. Suswa. *Studies in Speleology* 1(1):51-66.
- Goldstein, S. T.
2014 Quantifying endscraper reduction in the context of obsidian exchange among early pastoralists in southwestern Kenya. *Lithic Technology* 39(1):3-19.
- Goldstein, S. T. and Munyiri, J.
2017 The Elmenteitan Obsidian Quarry (GsJj50): New perspectives on obsidian access and exchange during the Pastoral Neolithic in southern Kenya. *African Archaeological Review* 34(1):43-73.
- Goldstein, S. T. and Shaffer, C. S.
2016 Experimental and archaeological investigations of backed microlith function among Mid-to-Late Holocene herders in southwestern Kenya. *Archaeological and Anthropological Sciences*. doi: 10.1007/s12520-016-0329-9.
- Goodale, N. and Andrefsky Jr, W. (Eds.)
2015 *Lithic Technological Systems and Evolutionary Theory*. Cambridge: Cambridge University Press.
- Goodyear, A. C.
1993 Tool kit entropy and bipolar reduction: A study of interassemblage lithic variability among Paleo-Indian sites in the northeastern United States. *North American Archaeologist* 14(1):1-23.
- Gopher, A. and Barkai, R.
2011 Sitting on the tailing piles: creating extraction landscapes in Middle Pleistocene quarry complexes in the Levant. *World Archaeology* 43(2):211-229.

- Gould, R.A. and Saggers, S.
1985 Lithic procurement in Central Australia: a closer look at Binford's idea of embeddedness in archaeology. *American Antiquity* 50(1):117-136.
- Gramly R. M.
1975a Meat-feasting sites and cattle brands: Patterns of rock-shelter utilization in East Africa. *Azania* 10:107–121.

1975b Pastoralists and hunters: Recent prehistory in southern Kenya and Tanzania. Doctoral dissertation, Harvard University. Boston: Harvard University.

1984 Mount Jasper: a direct-access lithic source area in the White Mountains of New Hampshire. In *Prehistoric quarries and lithic production*, edited by E. Ericson and B. A. Purdy, pp. 11-21. Cambridge: Cambridge University Press.
- Grillo, K. M.
2012 The Materiality of Mobile Pastoralism: Ethnoarchaeological Perspectives from Samburu, Kenya. Ph.D Dissertation, Washington University in St. Louis.

2014 Pastoralism and pottery use: an ethnoarchaeological study in Samburu, Kenya. *African Archaeological Review* 31(2):105-130.
- Grimm, L.
2000 Apprentice flintknapping: Relating material culture and social practice in the Upper Paleolithic. In *Children and Material Culture*, edited by J. S. Derevenski, pp. 53-71. New York: Routledge.
- Gulliver, P. H.
1971 *Neighbours and networks: The idiom of kinship in social action among the Ndendeuli of Tanzania*. Berkeley: University of California Press.
- Gutherz, X. and Jallot, L.
2011 *Les abris ornés de Laas Geel et l'art rupestre du Somaliland*. Montpellier: Presses Universitaires de la Méditerranée,
- Hammerstedt, S. W. and Hughes, E. R.
2015 Mill Creek Chert Hoes and Prairie Soils: Implications for Cahokian Production and Expansion. *Midcontinental Journal of Archaeology* 40(2):149-165.
- Hanotte, O., D. G. Bradley, J. W. Ochieng, Y. Verjee, E. W. Hill and J. E. O. Rege
2002 African Pastoralism: Genetic Imprints of Origins and Migrations. *Science* 296:336-339.

- Hantman, J. L. and S. Plog
1982 The relationship of stylistic similarity and patterns of material exchange. In *Contexts for Prehistoric Exchange*, edited by J. E. Ericson and T. K. Earle, pp. 237-257. New York: Academic Press.
- Hayden, B.
2014 Social Complexity. In *The Oxford Handbook of the Archaeology and Anthropology of Hunter-Gatherers*, edited by V. Cummings, P. Jordan, and M. Zvelebil. Oxford: Oxford University Press.
- Hayden, B. and Cannon, A.
1984 Interaction inferences in archaeology and learning frameworks of the Maya. *Journal of Anthropological Archaeology* 3(4):325-367.
- Herskovits, M. J.
1926 The cattle complex in East Africa. *American Anthropologist* 28(3):494-528.
- Hildebrand, E. A. and Grillo, K. M.
2012 Early herders and monumental sites in Eastern Africa: dating and interpretation. *Antiquity* 86:338-352.
- Hildebrand, E. A., Shea, J. J., & Grillo, K. M.
2011 Four middle Holocene pillar sites in West Turkana, Kenya. *Journal of Field Archaeology* 36(3):181-200.
- Hiscock, P.
2014 Learning in lithic landscapes: a reconsideration of the hominid “toolmaking” niche. *Biological Theory* 9(1):27-41.
- Hitchcock, R. K., & Bartram, L. E.
1998 Social boundaries, technical systems, and the use of space and technology in the Kalahari. In *The archaeology of social boundaries*, edited by M. Stark, pp. 12 - 49. Washington: Smithsonian Institution Scholarly Press.
- Hodder, I.
1982 *Symbols in action: ethnoarchaeological studies of material culture*. Cambridge: Cambridge University Press.

1991 Interpretive archaeology and its role. *American Antiquity* 56(1): 7-18.
- Hodgson, D. L.
2011 *Being Maasai, Becoming Indigenous: Postcolonial politics in a Neoliberal World*. Bloomington: Indiana University Press.

- Hoffman, R., Sobel, M. and Teute, F. J. (eds.)
1997 *Through a Glass Darkly: Reflections on Personal Identity in Early America*. Chapel Hill: UNC Press Books.
- Hogg, A. G., Hua, Q., Blackwell, P. G., Niu, M., Buck, C. E., Guilderson, T. P., Heaton, T. J., Palmer, J. G., Reimer, P. J., Reimer, R.W., Turney, C. S. M., & Zimmerman, S. R. H.
2013 SHCal13 Southern Hemisphere Calibration, 0-50,000 Years cal BP. *Radiocarbon* 55: 1-15.
- Holdaway, S., Wendrich, W., and R. Phillipps.
2010 Identifying low-level food producers: detecting mobility from lithics. *Antiquity* 84(3):185-194.
- Holmes, W.H.
1919 Handbook of Aboriginal American Antiquities. *Bureau of American Ethnology, Bulletin 60*.
- Homewood, K. M.
2008 *Ecology of African pastoralist societies*. Athens: Ohio University Press.
- Homewood, K. M., Chenevix-Trench, P., and Brockington, D.
2012 Pastoralist livelihoods and wildlife revenue in East Africa: a case for coexistence? *Pastoralism: Research, Policy and Practice* 2:19.
- Honeychurch, W.
2014 Alternative complexities: The archaeology of pastoral nomadic states. *Journal of Archaeological Research* 22:277-326.
- Horowitz, R. A.
2015 Production at the source: Lithic extraction and production at Callar Creek Quarry, Belize. *Research Reports in Belizean Archaeology* (12):45-54.
- Hughes, R. E.
1978 Aspects of prehistoric Wiyot exchange and social ranking. *Journal of California Anthropology* 5(1):53-66.
- Hughes, K.
2016 Rights, Wrongs, and Reciprocity. *The Moral Economies of Ethnic and Nationalist Claims: The Moral Economies of Ethnic and Nationalist Claims*, 70.
- Ingold, T.
1980 *Hunters, pastoralists, and ranches: reindeer economies and their transformations*. Cambridge: Cambridge University Press.

1993 The temporality of the landscape. *World Archaeology* 25(2): 152-174.

- Jackson, T. L., and Ericson, J. E.
1994 Prehistoric exchange systems in California. In *Prehistoric Exchange Systems in North America*, edited by T. G. Baugh and J. E. Ericson, pp. 385-415. New York: Springer.
- Jarman, M. R.
1972 A territorial model for archaeology: a behavioural and geographical approach. In *Models in archaeology*, edited by D. Clark, pp.705-733. New York: Routledge.
- Johnson, J. K.
1987 Cahokia core technology in Mississippi: the view from the South. In *The Organization of Core Technology*, edited by J. K. Johnson and C. A. Morrow, pp.187–206. Boulder: Westview Press
- Johnson, T., Werne, J. P., Brown, E. T., Abbott, A., Berke, M., Steinman, B. A., & Scholz, C. A.
2016 A progressively wetter climate in southern East Africa over the past 1.3 million years. *Nature* 537(7619):220-224.
- Julien, C. K., and Julien, M.
1994 Prehistoric technology: A cognitive science? In *The Ancient Mind, Elements of Cognitive Archaeology*, edited by C. Renfrew and E. Zubrow, pp.152-163. Cambridge: Cambridge University Press.
- Karenga-Münene, A.
2002 *Holocene Foragers, Fishers, and Herders of Western Kenya*. BAR International Series 1037. Cambridge Monographs in African Archaeology 54. Oxford: Archaeopress.
- Karlén, W., Fastook, J. L., Holmgren, K., Malmström, M., Matthews, J. A., Odada, E., Risberg, J., Rosqvist, G., Sandgren, P. and Shemesh, A.
1999 Glacier Fluctuations on Mount Kenya since-6000 Cal. Years BP: Implications for Holocene Climatic Change in Africa. *Journal of Human Environment Research and Management* 28(5):409-418.
- Karlin, C. and Julien, M.
1994 Prehistoric technology: a cognitive science. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew, pp.152-164. Cambridge: Cambridge University Press.
- Kassam, A. and Balla-Bashuna, A.
2004 Marginalisation of the Waata Oromo hunter-gatherers of Kenya: insider and outsider perspectives. *Africa* 74(2):194-216.
- Kay, M., & Solecki, R.
2000 Pilot study of burin use-wear from Shanidar Cave, Iraq. *Lithic Technology* 25:30-41.

- Keeley, L. H.
1982 Hafting and retooling: effects on the archaeological record. *American Antiquity* 47(4):798-809.
- Kelly, R. L.
1988 The three sides of a biface. *American Antiquity* 43(4):717-734.

1992 Mobility/Sedentism: concepts, archaeological measures, and effects. *Annual Reviews of Anthropology* 21:43-66.
- The Kenya Gazette
1965 The Animal Diseases Act, 1965. November 23, 1965. *The Kenya Gazette* 67(54):1405.
- Klumpp, D. and Kratz, C.
1993 Aesthetics, expertise and ethnicity: Okiek and Maasai perspectives on personal ornament. In *Being Maasai: Ethnicity and Identity in East Africa*, edited by T. Spear and R. Waller, pp.195-221. Nairobi: East African Educational Publishers.
- Kobayashi, T.
1970 Microblade industries in the Japanese archipelago. *Arctic Anthropology* 7(2):38-58.
- Kuhn, S. L.
1991 "Unpacking" reduction: lithic raw material economy in the Mousterian of west-central Italy. *Journal of Anthropological Archaeology* 10(1):76-106.

2014 *Mousterian lithic technology: an ecological perspective*. Princeton: Princeton University Press.
- Kuhn, S. L., and D. S. Miller.
2015 Artifacts as patches: the marginal value theorem and stone tool life histories. In. *Lithic Technological Systems and Evolutionary Theory*, edited by N. Goodale and W. Andrefsky Jr, pp.172-197. Cambridge: Cambridge University Press.
- Lamont, M.
1992 *Money, morals, and manners: The culture of the French and the American upper-middle class*. Chicago: University of Chicago Press.
- Lane, P. J.
2004 The 'moving frontier' and the transition to food production in Kenya. *Azania* 39:243-64.

2011 An outline of the Late Holocene archaeology and precolonial history of the Ewaso Basin, Kenya. *Smithsonian Contributions to Zoology* 632:11-30.

- Lane, P. J., Ashley, C., Seitsonen, O., Harvey, P., Mire, S., & Odede, F.
2007 The transition to farming in eastern Africa: new faunal and dating evidence from Wadh Lang'o and Usenge, Kenya. *Antiquity* 81:62-81.
- Langdon, J. and Robertshaw, P.
1985 Petrographic and physico-chemical studies of early pottery from south-western Kenya. *AZANIA* 20(1): 1-28.
- Larick, R.
1985 Spears, style, and time among Maa-speaking pastoralists. *Journal of Anthropological Archaeology* 4(3):206-220.
- Lassen, R. and Williams, T.
2015 Variation in flintknapping skill among Folsom-era projectile point types: A quantitative approach. *Journal of Archaeological Science: Reports* 4:164-173.
- Lave, J. and Wenger, E.
1991 *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
- LaViolette, A., & Fleisher, J.
2005 The archaeology of sub-Saharan urbanism: Cities and their country sides. *African archaeology: A critical introduction*, edited by A. Stahl, pp. 327-352. Boston: Wiley-Blackwell.
- Lawrence, D. and Wilkinson, T.J.
2015 Hubs and upstarts: pathways to urbanism in the northern Fertile Crescent. *Antiquity* 89(344):328-44.
- Leakey, L. S. B.
1927 Stone Age man in Kenya colony. *Nature* 120: 85-86.
1931 *The Stone Age Cultures of Kenya Colony*. Cambridge: Cambridge University Press.

1935 *The Stone Age Races of Kenya*. Oxford: Oxford University Press.
- Leakey, L. S. B. & Leakey, M. D.
1950 *Excavations at the Njoro River Cave: Stone Age burials in Kenya colony*. London: Clarendon Press.
- Leakey, M. D.
1945 Report on the excavations at Hyrax Hill, Nakuru, Kenya Colony. *Transactions of the Royal Society of South Africa* 30:271-409.
- Lee, R. B.
1972 !Kung spatial organization: An ecological and historical perspective. *Human Ecology* 1(2):125-47.

- Lemonnier, P.
 1986 The study of material culture today: toward an anthropology of technical systems. *Journal of Anthropological Archaeology* 5(2):147-186.
 1993 *Technological choices: transformations in material cultures since the Neolithic*. New York: Routledge.
- Lengyel, G. and Chu, W.
 2016 Long thin blade production and Late Gravettian hunter-gatherer mobility in Eastern Central Europe. *Quaternary International* 406:166-173.
- Leroi-Gourhan, A.
 1964 *Les religions de la préhistoire: paléolithique* (Vol. 51). Paris: Presses univ. de France.
- Lesorogol, C. K.
 2003 Transforming institutions among pastoralists: inequality and land privatization. *American Anthropologist* 105(3):531-541.
- Lesur, J., Hildebrand, E. A., Abawa, G., & Guthertz, X.
 2014 The advent of herding in the Horn of Africa: New data from Ethiopia, Djibouti and Somaliland. *Quaternary International* 343:148-158.
- Lesur-Gebremariam, J.
 2010 Domestication animale en Afrique. *Les nouvelles de l'archéologie* 120-121:38-46.
- Li, F., Kuhn, S.L., Chen, F.Y. and Gao, X.
 2016 Raw material economies and mobility patterns in the Late Paleolithic at Shuidonggou locality 2, north China. *Journal of Anthropological Archaeology* 43:83-93.
- Lightfoot, K.G., Martinez, A. and Schiff, A.M.
 1998 Daily practice and material culture in pluralistic social settings: an archaeological study of culture change and persistence from Fort Ross, California. *American Antiquity* 63(2):199-222.
- Linseele, V.
 2004 Size and size change of the African Aurochs during the Pleistocene and Holocene. *Journal of African Archaeology* 2(2):165-185.
- Lillehammer, G.
 1989 A child is born. The child's world in an archaeological perspective. *Norwegian Archaeological Review* 22(2):89-105.

- Lin, S. C. H., Douglass, M. J., Holdaway, S. J., Floyd, B.
2010 The application of 3D laser scanning technology to the assessment of ordinal and mechanical cortex quantification in lithic analysis. *Journal of Archaeological Science* 37:694-702.
- Little, P. D.
1996 Pastoralism, biodiversity and the shaping of savanna landscapes in East Africa. *Africa* 66:37-50.

1998 Maasai identity on the periphery. *American Anthropologist* 100(2):444-457.
- Liu, L., Chen, X. and Ji, P.
2016 Understanding household subsistence activities in Neolithic Inner Mongolia, China: Functional analyses of stone tools. *Journal of Anthropological Research* 72(2): 226-247.
- Loring, S.
1985 Boundary Maintenance, Mortuary Ceremonialism and Resource Control in the Early Woodland: Three Cemetery Sites in Vermont. *Archaeology of Eastern North America* 13:93-127.
- Lycett, S. J., Cramon-Taubadel, N. V. and J. A. J. Gowlett
2010 A comparative 3D geometric morphometric analysis of Victoria West cores: implications for the origins of Levallois technology. *Journal of Archaeological Science* 37:1110-1117.
- Lycett, S. J. and von Cramon-Taubadel, N.
2015 Toward a “quantitative genetic” approach to lithic variation. *Journal of Archaeological Method and Theory*, 22(2): 646-675.
- Lyman, R. L.
1994 Quantitative units and terminology in zooarchaeology. *American Antiquity* 59:36-71.
- Lyons, William H.
1994 Lithic technology at the Hall Creek Site (35GR420B), Silvies Valley, Grant County, Oregon. M.A. thesis, Washington State University, Pullman.
- Magne, Martin P., and David Pokotylo
1981 A pilot study in bifacial lithic reduction sequences. *Lithic Technology* 10:34–47.
- Manning, K. and Timpson, A.
2014 The demographic response to Holocene climate change in the Sahara. *Quaternary Science Reviews* 101:28-35.

- Mapinduzi, A. L., Oba, G., Weladji, R. B., and Colman, J. E.
2003 Use of indigenous ecological knowledge of the Maasai pastoralists for assessing rangeland biodiversity in Tanzania. *African Journal of Ecology* 41:329-336.
- Marean, C.
1992 Hunter to herder: Large mammal remains from the hunter-gatherer occupation at Enkapune Ya Muto rockshelter (Central Rift, Kenya). *African Archaeological Review* 10:65-127.
- Marshall, F. B.
1986 Implications of bone modification in a Neolithic faunal assemblage for the study of early hominid butchery and subsistence practices. *Journal of Human Evolution* 15(8): 661-672.

1990 Origins of specialized pastoral production in East Africa. *American Anthropologist* 92(4):873-94.

1994 Archaeological Perspectives on East African Pastoralism. In *African Pastoralist Systems*, edited by E. Fratkin, J. Galvin and E. Roth, pp. 17-44. Boulder: Lynne-Reinner.

2000 The origins and spread of domestic animals in East Africa. In *The origins and development of African livestock: Archaeology, genetics, linguistics and ethnography*, edited by R. Blench and K. MacDonald, pp.191-221. New York: Routledge.

2007 African pastoral perspectives on domestication of the donkey: a first synthesis. In *Rethinking agriculture: archaeological and ethnoarchaeological perspectives*, edited by T. Denham, J. Iriarte, & L. Vrydraghs (pp. 371-407). Walnut Creek: Left Coast Press.
- Marshall, F. B. and Hildebrand, E. A.
2002 Cattle before crops: The beginnings of food production in Africa. *Journal of World Prehistory* 16(2):99-143.
- Marshall, F. B. and Negash, A.
2002 Early hunters and herders of northern Ethiopia: The fauna from Danei Kawlos and Baati Ataro rockshelters. Paper presented at the Society of Africanist Archaeologists meeting, Tuscon, Arizona, USA.
- Marshall, F. B. and Weissbrod, L.
2011 Domestication processes and morphological change. *Current Anthropology*, 52(S4):S397-S413.
- Marshall, F. B., Grillo, K. M. and Arco, L.
2011 Prehistoric pastoralists and social responses to climatic risk in East Africa. In *Sustainable lifeways: Cultural persistence in an ever-changing environment*, N. Miller, K. Moore and K. Ryan, pp. 39-74. Philadelphia: University of Pennsylvania Museum of Archaeology and Anthropology Series, Penn Press.

- Marshall, F., Stewart, K. and Barthelme, J.
1984 Early domestic stock at Dongodien in northern Kenya. *Azania* 19(1):120-127.
- Mauss, M.
1954 *The Gift: Forms and functions of exchange in archaic societies*. London: Routledge.
- Mbae, N. B.
1986 Aspects of Maasai Ethnoarchaeology for Archaeological Interpretation. Masters Thesis. University of Nairobi.

1990 The ethnoarchaeology of Maasai settlements and refuse disposal patterns in the Lemek area. In *Early pastoralists of south-western Kenya*, edited by P. Robertshaw, pp. 279-92. Nairobi: Memoirs of the British Institute in Eastern Africa, 11.
- McBrearty S., and Brooks, A. S.
2000 The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution* 39(5):453-563.
- McCabe, J. T.
2004 *Cattle bring us to our enemies: Turkana ecology, politics, and raiding in a disequilibrium system*. Ann Arbor: University of Michigan Press.
- McCall, G. S.
2012 Ethnoarchaeology and the organization of lithic technology. *Journal of Archaeological Research* 20(2):157-203.
- McCoy, M. D., Mills, P. R., Lundblad, S., Rieth, T., Kahn, J. G., & Gard, R.
2011 A cost surface model of volcanic glass quarrying and exchange in Hawai'i. *Journal of Archaeological Science* 38(10):2547-2560.
- McDonald, M. M. A.
1992 Neolithic of Sudanese tradition or Saharo-Sudanese Neolithic? The view from Dakhla Oasis, south central Egypt. In *An African Commitment: Papers in Honour of Peter Louis Shinnie*, edited by J. Stenner, J and N. David, pp. 51-70. Calgary: University of Calgary Press.

1998a Early African pastoralism: View from Dakhleh Oasis (south central Egypt). *Journal of Anthropological Archaeology* 17: 124–142.

1998b Adaptive variability in the eastern Sahara during the early Holocene. In *Before Food Production in North Africa*, edited by S. di Lernia and G. Manzi, pp. 127–136. Union Internationale des Sciences Prehistoriques et Protohistoriques, XIII World Congress, Forli, Edizioni,

- McIntosh, R.J.
2005 *Ancient Middle Niger: Urbanism and the self-organizing landscape*. Cambridge: Cambridge University Press.
- Mehlman, M. J.
1989 Later Quaternary archaeological sequences in northern Tanzania. Unpublished Ph.D dissertation. University of Illinois at Urbana-Champaign.
- Merrick, H. V., and Brown, F. H.
1984 Obsidian sources and patterns of source utilization in Kenya and northern Tanzania: Some initial findings. *African Archaeological Review* 2:129-52.
- Merrick, H. V., Brown, F. H. and Connelly, M.
1990 Sources of the obsidian at Ngamuriak and other Southwestern Kenyan sites. In *Early pastoralists of south-western Kenya*, edited by P. Robertshaw, pp. 173-182. Nairobi: Memoirs of the British Institute in Eastern Africa, 11.
- Merrick, H. V. & Monaghan, M. C.
1984 The date of the cremated burials in Njoro River Cave. *Azania* 19(1):7-11.
- Meskel, L.
2005 Introduction: Object orientations. In *Archaeologies of Materiality*, edited by L. Meskel. pp. 1-11. Oxford: Blackwell Publishing Ltd.
- Messineo, P. G. and Barros, M. P.
2015 Lithic raw materials and modes of exploitation in quarries and workshops from the center of the Pampa grasslands of Argentina. *Lithic Technology* 40(1):3-20.
- Miller, D.
2005 The limits of dominance. In *Domination and resistance*, edited by D. Miller, M. Rowlands, and C. Tilley, pp. 63-77. New York: Routledge.
- Milne, S. B.
2012 Lithic raw material availability and palaeo-Eskimo novice flintknapping. In *Archaeology and Apprenticeship: Body knowledge, Identity, and Communities of Practice*, edited by W. Wendrich, pp.119-144. Tuscon: The University of Arizona Press.

2013 Paleo-Eskimo novice flintknapping in the Eastern Canadian Arctic. *Journal of Field Archaeology* 3:330-345.
- Minar, C. J. and Crown, P. L.
2001 Learning and Craft Production: An Introduction. *Journal of Anthropological Archaeology* 57(4):369-80.

- Mohammed-Ali, A. S. and Khabir, A. R. M.
2003 The wavy line and the dotted wavy line pottery in the prehistory of the Central Nile and Sahara-Sahel belt. *African Archaeological Review* 20(1):25-58.
- Morales, J. I., Soto, M., Lorenzo, C., & Vergès, J. M.
2015 The evolution and stability of stone tools: The effects of different mobility scenarios in tool reduction and shape features. *Journal of Archaeological Science: Reports* 3:295-305.
- Morrow, C. A.
1987 Blades and Cobden chert: A technological argument for their role as markers of regional identification during the Hopewell period in Illinois. In *The Organization of Core Technology*, edited by J. K Johnson and C. A. Morrow, pp. 119-150. Boulder: Westview Press.

1997 End scraper morphology and use-life: an approach for studying Paleoindian lithic technology and mobility. *Lithic Technology* 22(1):70-85.
- Moutsiou, T.
2012 Changing scales of obsidian movement and social networking. In *Unravelling the Palaeolithic: Ten Years of Research at the Centre for the Archaeology of Human Origins (CAHO, University of Southampton)*, edited by K. Ruebens, R. Bynoe and I. Romanowska, pp. 85-95. London: British Archaeological Reports.
- Mturi, A. A.
1986 The pastoral neolithic of West Kilimanjaro. *Azania* 21(1): 53-63.
- Müller-Wille, L.
1989 Place names, territoriality and sovereignty: Inuit perception of space in Nunavik (Canadian Eastern Arctic). *Schweizerische Amerikanisten-Gesellschaft Bul.* 43-54:17-21.
- Mutundu, K. K.
1998 *Ethnohistoric archaeology of the Mukogodo in North-Central Kenya: contemporary hunter-gatherer subsistence and the transition of pastoralism in secondary settings*. PhD Dissertation, Washington University in St. Louis
- Nash, B. P., Merrick, H. V., & Brown, F. H.
2011 Obsidian types from Holocene sites around Lake Turkana, and other localities in northern Kenya. *Journal of Archaeological Science* 38(6):1371-1376.
- Ndagala, D. K.
1992 Territory, pastoralists, and livestock: Resource Control among the Maasai. *Uppsala Studies in Cultural Anthropology* 18.

- Ndiema, E., Dillian, C. D., & Braun, D. R.
2010 Interaction and exchange across the transition to pastoralism, Lake Turkana, Kenya. In *Trade and Exchange: Studies from History and Prehistory*, edited by C. D. Dillian and C. L. White, pp.95-110. New York: Springer.
- Nelson, C. M.
1973 A comparative analysis of 29 Later Stone Age occurrences from East Africa. Unpublished doctoral dissertation, Berkeley: Department of Anthropology, University of California, Berkeley.

1980 The Elmenteitan lithic industry. In *Proceedings of the 8th Panafrican Congress of Prehistory and Quaternary Studies, Nairobi, September 1977*, edited by R. E. Leakey and B. A. Ogot, pp. 275-78. Nairobi: The International Louis Leakey Memorial Institute for African Prehistory.
- Nelson, M.
1991 The Study of Technological Organization. *Archaeological Method and Theory* 3:57-100.
- Nicholaisen, J.
1963 *Ecology and culture of the pastoral Tuareg, with particular reference to the Tuareg of Ahaggar and Ayr*. Etnografisk Raekke, 9. Copenhagen: National Museums of Copenhagen.
- Nicholson, S. E.
1996 A review of climate dynamics and climate variability in Eastern Africa. In *The limnology, climatology and paleoclimatology of the East African lakes*, edited by T. Johnson and E. Odada, pp.25-56. Milton Park: CRC Press.
- Odner, K.
1972 Excavations at Narosura, a stone bowl site in the southern Kenya highlands. *Azania* 7(1):25-92.
- Oka, R. and Kusimba, C.M.
2008 The archaeology of trading systems, part 1: towards a new trade synthesis. *Journal of Archaeological Research* 16(4):339-395.
- Olago, D., Opere, A., and Barongo, J.
2009 Holocene paleohydrology, groundwater, and climate change in the lake basins of the Central Kenya Rift. *Hydrological Sciences* 54(5):765-780.
- Onyango-Abuje, J. C.
1977 Crescent Island: A preliminary report on excavations at an East African Neolithic site. *Azania* 12(1):147-159.

- Ortmann, A. L. and Kidder, T. R.
 2013 Building Mound A at Poverty Point, Louisiana: Monumental public architecture, ritual practice, and implications for hunter-gatherer complexity. *Geoarchaeology* 28:66-86.
- O'Shea, J.
 1981 Coping with scarcity: exchange and social storage. In *Economic archaeology: towards an integration of ecological and social approaches*, edited by A. Sheridan and G. Bailey, pp.167-83. London: British Archaeological Reports.
- Parry, W. J., and Kelly, K. L.
 1987 Expedient core technology and sedentism. In *The organization of core technology*, edited by J. K Johnson and C. M. Morrow, pp. 285-304. Boulder, CO: Westview Press.
- Pelcin, A. W.
 1997 The effect of core surface morphology on flake attributes: evidence from a controlled experiment. *Journal of Archaeological Science* 24(8):749-756.
- Pelegrin, J.
 1990 Prehistoric lithic technology: some aspects of research. *Archaeological Review from Cambridge* 9(1):116-125.
- Pelegrin, J., Karlin, C. and P. Bodu.
 1988 Chaines operatoires: un outil pour le prehistorien. In *Technologie prehistorique*, edited by J. Tixier, pp. 55-62. Paris: Editions du CNRS.
- de la Peña, P.
 2011 Sobre la identificación macroscópica de las piezas astilladas: Propuesta experimental. *Trabajos de Prehistoria* 68:79-98.
 2015 A qualitative guide to recognize bipolar knapping for flint and quartz. *Lithic Technology* (40)4, 316-331.
- Peristiany, J.G.
 1951 The Age-Set System of the Pastoral Pokot: The Sapana Initiation Ceremony. *Africa* 21(3):188-206.
- Peters, J.
 1991 The faunal remains from Shaqadud. In *The Late Prehistory of the Eastern Sahel*, edited A.E. Marks and A. Mohammed-Ali, pp. 197-235. Dallas: Southern Methodist University Press.
- Phillipson, D. W.
 1976 *The prehistory of Eastern Africa*. Nairobi: British Institute in Eastern Africa. Memoir 6.

- 1977 Lowasera. *Azania* 12(1):1-32.
- Pigeot, N.
1990 Technical and social actors. Flintknapping specialists and apprentices at Magdalenian Etiolles. *Archaeological Review from Cambridge* 9(1):126-141.
- Pinkerton, H., Norton, G.E., Dawson, J.B. & Pyle, D.M.,
1995 Field observations and measurements of the physical properties of Oldoinyo Lengai alkali carbonatite lavas, November 1988. In *Carbonatite Volcanism*, edited by K. Bell & J. Keller, pp.23-36. Berlin: Springer.
- Polyani, K.
1944 *The Great Transformation: The Political and Economic Origin of Our Times*. Boston: Beacon Press.

1957 The Economy as Instituted Process. In *Primitive, Archaic, and Modern Economies*, edited by G. Dalton, pp. 139-174. Boston: Beacon Press.
- Porr, M.
2005 The making of the biface and the making of the individual. In *The Hominid Individual in Context: Archaeological investigations of Lower and Middle Palaeolithic landscapes, locales and artefacts*, edited by C. Gamble and M. Poor, pp. 68-80. London & New York: Routledge.
- Prendergast, M. E.
2009 Forager variability and transitions to food production in secondary settings: Kansyore and Pastoral Neolithic economies in East Africa. *Azania* 44:276-77.
- Prendergast, M. E., & Mutundu, K. K.
2009 Late Holocene zooarchaeology in East Africa: Ethnographic analogues and interpretive challenges. *Documenta Archaeobiologiae* 7:203-232.
- Prendergast, M. E., Mabulla, A. Z. P., Grillo, K. M., Broderick, L. G., Seitsonen, O., Gidna, A. O., & Gifford-Gonzalez, D.
2013 Pastoral Neolithic sites on the southern Mbulu Plateau, Tanzania. *Azania* 48(4): 498-520.
- Purdy, B. A.
1984 Quarry studies: technological and chronological significance. In *Prehistoric quarries and lithic production*, J. E. Ericson and B. A. Purdy, pp. 119-127. Cambridge: Cambridge University Press.
- Quintero, L.A.,
2010 *Evolution of lithic economies in the Levantine Neolithic: development and demise of Naviform core technology, as seen at 'Ain Ghazal*. Berlin: Ex Oriente.

- Quintero, L. A. and Wilke, P. J.,
1995 Evolution and economic significance of naviform core-and-blade technology in the southern Levant. *Paléorient* 21(1):17-33.
- Reitz, E. J., and Wing, E. S.
2008 *Zooarchaeology*. Cambridge Manuals in Archaeology. Cambridge: Cambridge University Press.
- Ren, M., Omenda, P. A., Anthony, E. Y., White, J. C., MacDonald, R., Bailey, D. K.
2006 Application of the QUILF thermobarometer to the peralkaline trachytes and pantellerites of the Eburru volcanic complex, East African Rift, Kenya. *Lithos* 91, 109-124.
- Renfrew, C.
1977 Alternative models for exchange and spatial distribution. In *Exchange Systems in Prehistory*, edited by T. K. Earle and J. E. Ericson, pp.71-89. New York: Academic Press

1985 *Approaches to social archaeology*. Edinburgh: Edinburgh University Press.

1986 Varna and the emergence of wealth in prehistoric Europe. In *The social life of things: commodities in cultural perspective*, edited by A. Appadurai, pp.141-167. Cambridge: Cambridge University Press.
- Rigby, P.
1983 Time and historical consciousness: the case of Ilparakuyo Maasai. *Comparative Studies in Society and History* 25(3):428-456.
- Robbins, L.
1974 *The Lothagam site: A Late Stone Age fishing settlement in the Lake Rudolph Basin, Kenya*. Detroit: Michigan State University Press.
- Robbins, P.
2006 *Red Spotted Ox: A Pokot life*. Copenhagen: IWGIA.
- Robertshaw, P. T.
1988 The Elmenteitan: An early food-producing culture in East Africa. *World Archaeology* 20(1):57-69.

1990 *Early pastoralists of southwestern Kenya*. Nairobi: Memoirs of the British Institute in Eastern Africa, 11.

1991 Gogo Falls: Excavations at a complex archaeological site east of Lake Victoria. *Azania* 26:63-195

- Robertshaw, P. T., and Collett, D. T.
1983 The identification of pastoral peoples in the archaeological record: An example from East Africa. *World Archaeology* 15:67-78.
- Robertshaw, P. T., & Wetterstrom, W.
1989 Plant remains from Gogo Falls. *Nyame Akuma* 31:25-27.
- Root, M. J.
1997 Production for exchange at the Knife River flint quarries, North Dakota. *Lithic Technology* 22:33-50.
- Roux, V., B., Brill, and G. Dietrich
1995 Skills and learning difficulties involved in stone knapping: The case of stone-bead knapping in Khambhat, India. *World Archaeology* 27:63-87.
- Roux, V. and David, E.
2005 Planning abilities as a dynamic perceptual-motor skill: An actualist study of different levels of expertise involved in stone knapping. In *Stone knapping: The necessary conditions for a uniquely hominin behavior*, edited by V. Roux and D. Brill, pp:91-116. Cambridge: McDonald Institute for Archaeological Research.
- Rowley-Conwy, P.
2011 Westward ho! *Current Anthropology* 52(S4):S431-S451.
- Sahlins, M. D.
1972 *Stone age economics*. London: Aldine Transaction Publishers.
- Sackett, J. R.
1999 *The archaeology of Solvieux*. Los Angeles: Institute of Archaeology, University of California at Los Angeles.
- Salzman, P. C.
1971 Movement and resource extraction among pastoral nomads: The case of the Shah Nawazi Baluch. *Anthropological Quarterly* 44(3):185-197.

1999 Is inequality universal? *Current Anthropology* 40(1):31-61.
- Saxe, A. A.
1970 Social dimensions of mortuary practices. Doctoral Dissertation, University of Michigan. Ann Arbor: University Microfilms.
- Schneider, H. K.
1979 *Livestock and equality in East Africa: the economic basis for social structure*. Bloomington: Indiana University Press.

- Schortman, E. M., & Urban, P. A.
 2004. Modeling the roles of craft production in ancient political economies. *Journal of Archaeological Research* 12(2):185-226.
- 2012 Enacting power through networks. *Journal of Anthropological Archaeology* 31(4):500-514.
- Sealy, J. and Yates, R.
 2015 The chronology of the introduction of pastoralism to the Cape, South Africa. *Antiquity* 68(258):58-67.
- Seitsonen, O.
 2006 Archaeological research in the northern Lake Manyara Basin, Tanzania 2003–2004. *Azania* 41(1):41-67.
- 2010 Lithics use at Kansyore sites in East Africa: Technological organisation at four recently excavated sites in Nyanza Province, Kenya. *Azania* 45(1):49-82.
- Sellet, F.,
 1993 Chaîne opératoire; the concept and its applications. *Lithic Technology* 18(1-2):106-112.
- Shafer, H. J. and Hester, T. R.
 1991 Lithic craft specialization and product distribution at the Maya site of Colha, Belize. *World Archaeology* 23(1):79-97.
- Shahack-Gross, R., Marshall, F., Weiner, S.
 2003 Geo-ethnoarchaeology of pastoral sites: the identification of livestock enclosures in abandoned Maasai settlements. *Journal of Archaeological Science* 30:439-459.
- Shahack-Gross, R., Marshall, F., Ryan, K. and Weiner, S.
 2004 Reconstruction of spatial organization in abandoned Maasai settlements: implications for site structure in the Pastoral Neolithic of East Africa. *Journal of Archaeological Science* 31:1395-1411
- Shaw, I.
 1994 Pharaonic quarrying and mining: settlement and procurement in Egypt's marginal regions. *Antiquity* 68(258):108-119.
- Shea, J. J.
 2006 Child's play: reflections on the invisibility of children in the Paleolithic record. *Evolutionary Anthropology: Issues, News, and Reviews*, 15(6):212-216.
- 2010 Stone Age visiting cards revisited: A strategic perspective on the lithic technology of early hominin dispersal. In *Out of Africa I: The first hominin colonization of Eurasia*,

edited by J. G. Fleagle, J. J. Shea, F. E. Grine, A. L. Baden, and R. E. Leakey (pp. 47-64). Springer Netherlands.

Shelley, P. H.

1990 Variation in lithic assemblages: an experiment. *Journal of Field Archaeology* 17:187-93

Shennan, S.

2002 *Genes, memes, and human history: Darwinian archaeology and cultural evolution*. London: Thames & Hudson.

Shipman, P., Foster, G., & Schoeninger, M.

1984 Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. *Journal of Archaeological Science* 11(4):307-325.

Shipton, C., Helm, R., Boivin, N., Crowther, A., Austin, P., & Fuller, D. Q.

2013 Intersections, networks and the genesis of social complexity on the Nyali Coast of East Africa. *African Archaeological Review* 30(4):427-453.

Shott, M. J.

1986 Technological organization and settlement mobility: An ethnographic examination. *Journal of Anthropological Research* 42:15-51.

1989 On tool-class use lives and the formation of archaeological assemblages. *American Antiquity* 54(1):9-30.

1999 On bipolar reduction and splintered pieces. *North American Archaeologist* 20(3):217-238.

2003 Chaîne opératoire and reduction sequence. *Lithic Technology* 28(2):95-105.

2015 Glass is heavy, too: Testing the field-processing model at the Modena obsidian quarry, Lincoln County, Southeastern Nevada. *American Antiquity* 80(3):548-570.

Shott, M. J., and Olson, E. C.

2015 Scale of production at prehistoric quarries: A pilot study in extending the “analytical core unit” concept. *Lithic Technology* 40(3):218-230.

Shott, Michael J., Andrew P. Bradbury, Philip J. Carr, and George H. Odell

2000 Flake size from platform attributes: predictive and empirical approaches. *Journal of Archaeological Science* 27:877-94.

Simons, A.

2004 The Development of Early Pastoral Societies in South-Western Kenya: A study of the faunal assemblages from Sugunya and Oldorotua 1. Doctoral Dissertation, La Trobe University, Victoria, AU.

- 2005 Exchange networks, socio-political hierarchies and the archaeological evidence for differential wealth amongst pastoralists in south-western Kenya. *Nyame Akuma* 64:36-40.
- Slater, P. A.
2016 Change in lithic technological organization strategies during the Middle and Later Stone Ages in East Africa. Unpublished Doctoral dissertation, University of Illinois at Urbana-Champaign.
- Smith, A. B.
1980 *The Neolithic tradition of the Sahara*. Rotterdam: A. A. Balkema
1992 Origins and spread of pastoralism in Africa. *Annual Review of Anthropology* 21: 125-141.
- Spear, T.
1993 Introduction. In *Being Maasai: Ethnicity and identity in East Africa*, edited by T. Spear & R. D. Waller, pp.1–18. London: James Currey.
- Spear, T. and Waller, R.D. (eds.)
1993 *Being Maasai: Ethnicity and identity in East Africa*, London: James Currey.
- Specht, J., Fullagar, R., Torrence, R. and Baker, N.
1988 Prehistoric obsidian exchange on Melanesia: A perspective from the Talasea Sources. *Australian Archaeology* 27:3-16.
- Spielmann, K.A.
2002 Feasting, Craft Specialization, and the Ritual Mode of Production in Small-Scale Societies. *American Anthropologist* 104(1):195-207.
- Spence, M. W.
1982 The social context of production and exchange. *Contexts for Prehistoric Exchange*, edited by J. Ericson and T. K. Earle, pp. 173-197. New York: Academic Press.
- Spencer, P.
1965 *The Samburu: A study of gerontocracy in a nomadic tribe*. Berkeley: University of California Press.

1973 *Nomads in alliance: Symbiosis and growth among the Rendille and Samburu of Kenya*. London: Oxford University Press.

2004 *Time, space and the unknown: Maasai configurations of power and providence*. New York: Routledge.

2011 The Samburu Clan Census: genealogy and age among the Parpoda. Unpublished appendix to Spencer, P. *The Samburu* [1965].

- Sobania, N.
1991 Feasts, famines and friends: nineteenth century exchange and ethnicity in the Eastern Lake Turkana Region. In *Herders, warriors, and traders: Pastoralism in Africa*, edited by J. Galaty, J. and P. Bonte, pp. 118–145. New York: Westview Press.
- Sperling, L.
1987 *The labor organization of Samburu pastoralism*. PhD Dissertation, McGill University.
- Spielmann, K. A.
2002 Feasting, craft specialization, and the ritual mode of production in small-scale societies. *American Anthropologist* 104(1):195-207.
- Stahl, J.
2008 Who Were the Flintknappers? A Study of Individual Characteristics. *Lithic Technology*, 33(2): 161-172.
- Stevenson, C. M., Abdelrehim, I. and Novak, S. W.
2004 High precision measurement of obsidian hydration layers on artifacts from the Hopewell site using secondary ion mass spectrometry. *American Antiquity* 69(3):555-567.
- Stout, D.
2002 Skill and cognition in stone tool production: An ethnographic case study from Irian Jaya. *Current Anthropology* 43:693–722.

2005 The social and cultural context of stone-knapping skill acquisition. Stone knapping. In *Stone knapping: The necessary conditions for a uniquely hominin behavior*, edited by B. Bril and V. Roux, pp. 331-340. Cambridge: McDonald Institute Monograph Series.
- Strathern, A.
1971 *The rope of Moka: big-men and ceremonial exchange in Mount Hagen, New Guinea* (No. 4). Cambridge: Cambridge University Press.
- Summerhayes, G. R.
2004 The nature of prehistoric obsidian importation to Anir and the development of a 3,000 year old regional picture of obsidian exchange within the Bismarck Archipelago, Papua New Guinea. *Records of the Australian Museum, Supplement* 29:145-156.
- Surovell, T.
2003 The behavioral ecology of Folsom lithic technology. Unpublished doctoral dissertation. University of Arizona.

2012 Toward a behavioral ecology of lithic technology: cases from Paleoindian archaeology. Tuscon: The University of Arizona Press.

- Sutton, J. E. G.
1977 The African Aqualithic. *Antiquity* 51(201):25-34.
- 1993 Deloraine: Further excavations, and the Iron Age sequence of the Central Rift. *Azania* 18:103-125.
- Taşon, P. S.
2004 Ochre, clay, stone and art. In *Soils, stones and symbols: Cultural perceptions of the mineral world*, edited by N. Bovin and A. Owic, pp. 31-42. New York: Routledge.
- Tafuri, M. A., Bentley, R. A., Manzi, G. and Di Lernia, S.
2006 Mobility and kinship in the prehistoric Sahara: Strontium isotope analysis of Holocene human skeletons from the Acacus Mts.(southwestern Libya). *Journal of Anthropological Archaeology* 25(3):390-402.
- Takakura, J.
2013 Using lithic refitting to investigate the skill learning process: lessons from Upper Paleolithic assemblages at the Shirataki sites in Hokkaido, northern Japan. In *Dynamics of Learning in Neanderthals and Modern Humans, Cultural Perspectives*, edited by T. Akazawa, Y. Nishiaki, & K. Aoki, pp. 151-173. New York: Springer Science & Business Media.
- Thomson, J.
1887 *Through Masai land: A journey of exploration among the snowclad volcanic mountains and strange tribes of eastern equatorial Africa*. London: Sampson Low, Marston, Searle & Rivington.
- Thompson, L. G., Mosley-Thompson, E., Davis, M. E., Henderson, K.A., Brecher, H. H., Zagorodnov, V. S., Mashiotta, T. A., Lin, P. N., Mikhalenko, V. N., Hardy, D. R. and Beer, J.,
2002 Kilimanjaro ice core records: evidence of Holocene climate change in tropical Africa. *Science* 298(5593):589-593.
- Tierney, J. E., Smerdon, J. E., Anchukaitis, K. J., & Seager, R.
2013 Multidecadal variability in East African hydroclimate controlled by the Indian Ocean. *Nature* 493(7432):389-392.
- Tignor, R. L.
1972 The Maasai warriors: pattern maintenance and violence in colonial Kenya. *The Journal of African History*, 13(2):271-290.
- Topping, P. and Lynott, M. J. (Eds.)
2005. *The cultural landscape of prehistoric mines*. London: Oxbow Books Limited.

- Torrence, R.
 1984 Monopoly or direct access? Industrial organization at the Melos obsidian quarries. In *Prehistoric quarries and lithic production*, edited by J. E. Ericson and B. A. Purdy, pp. 49-64. Cambridge: Cambridge University Press.
- 1986 *Production and exchange of stone tools: Prehistoric obsidian in the Aegean*, Cambridge: Cambridge University Press.
- Tostevin, G. B.
 2013 *Seeing lithics: a middle-range theory for testing for cultural transmission in the Pleistocene*. Oakville, CT: Oxbow Books.
- Trigger, B.
 1989 *A history of archaeological thought*. 11th edition (2002). Cambridge: Cambridge University Press.
- Tripcevich, N.
 2007 Quarries, caravans, and routes to complexity: prehispanic obsidian in the south-central Andes. Unpublished Doctoral dissertation, University of California Santa Barbara.
- 2010 Exotic Goods, Chivay Obsidian, and Sociopolitical Change in the South-Central Andes. In *Trade and Exchange*, edited by C. D. Dillian and C. L. White, pp. 59-73. New York: Springer.
- Tripcevich, N. and Contreas, D. A.
 2013 Archaeological approaches to obsidian quarries: Investigations at the Quispisisa source. In *Mining and quarrying in the ancient Andes*, edited by N. Tripcevich and K. J. Vaughn, pp. 23-44. New York: Springer.
- Tripcevich, N. and Mackay, A.
 2011 Procurement at the Chivay obsidian source, Arequipa, Peru. *World Archaeology*, 43(2):271-297.
- Turton, D.
 1979 War, peace, and Mursi identity. *Senri Ethnological Studies* 3:179-210.
- van der Veen, M. (Ed.)
 1999 *The exploitation of plant resources in Africa*. New York: Springer.
- Verschuren, D.
 2001 Reconstructing fluctuations of a shallow East African lake during the past 1800 years from sediment stratigraphy in a submerged crater basin. *Journal of Paleolimnology* 25(3):297-311.

- Wallace, I. J. and Shea, J. J.
2006 Mobility patterns and core technologies in the Middle Paleolithic of the Levant. *Journal of Archaeological Science* 33:1293–1309.
- Walthall, J. A. and Koldehoff, B.
1998 Hunter-gatherer interaction and alliance formation: Dalton and the cult of the long blade. *The Plains Anthropologist* 43(165):257-273.
- Wandibba, S.
1980 The application of attribute analysis to the study of Later Stone Age/Neolithic pottery ceramics in Kenya. In *Proceedings of the Eighth Panafrican Congress of Prehistory and Quaternary Studies, Nairobi*, edited by R. E Leakey and B. Ogot, pp. 283-285. Nairobi: The International Louis Leakey Memorial Institute for African Prehistory.
- Want, S. C. and Harris, P. L.
2002 How do children ape? Applying concepts from the study of non-human primates to the developmental study of ‘imitation’ in children. *Developmental Science* 5(1):1-14.
- Weissbrod, L.
2010 *Biological indicators of occupation intensity: An environmental ethnoarchaeology of Maasai settlements*. Ph.D Dissertation, Washington University in Saint Louis.
- Weisler, M.
2011 A quarried landscape in the Hawaiian Islands. *World Archaeology* 43(2):298-317.
- Weedman, K.
2002a On the spur of the moment: Effects of age and experience on hafted stone scraper morphology. *American Antiquity* 67(4):731-744.

2002b An ethnoarchaeological study of stone-tool variability among the Gamo hideworkers of Southern Ethiopia. In *Le Travail du cuir: de la préhistoire à nos jours*, edited by S. Beyries and F. Audoin-Rouzeau, pp. 131-142. Antibes, Editions APDCA.
- Weldeab, S., Menke, V., & Schmiedl, G.
2014 The pace of East African monsoon evolution during the Holocene. *Geophysical Research Letters* 41(5):1724-1732.
- Wendorf, F.
1998 Nabta Playa and its Role in NE African Prehistory. *Journal of Anthropological Archaeology* 17:97–123.
- Wendorf, F., Schild, R., and Close, A. E.
1984 *Cattle-keepers of the eastern Sahara: the Neolithic of Bir Kiseiba*. Dallas: Southern Methodist University Press

- Wenger, E.
1998 *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.
- Western, D.
1982 The environment and ecology of pastoralists in arid savannas. *Development and Change* 13(2):183-211.
- Western, D. and Dunne, T.
1979 Environmental aspects of settlement site decisions among pastoral Maasai. *Human Ecology* 7(1):75-98.
- Wetterstrom, W.
1991 Appendix IV: plant remains from Gogo Falls. Gogo Falls: excavations at a complex archaeological site east of Lake Victoria. *Azania* 26:180-191.
- White, F.
1983 *The vegetation of Africa: A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa*. Paris: United Nations-UNESCO.
- Whittaker, J. C.
1987 Making arrowpoints in a prehistoric Pueblo. *Lithic Technology* 16(1):1-12.
- Wilk, R. R., & Cliggett, L. C.
2007 *Economies and cultures: foundations of economic anthropology*. Boulder: Westview Press.
- Willcox, G.
2013 The beginnings of cereal cultivation and domestication in southwest Asia. In *A Companion to the Archaeology of the Ancient Near East*, edited by D. T. Potts, pp. 163-180. Chicago: Blackwell.
- Willman, J. C., Shackelford, L. and Demeter, F.
2016 Incisor ablation among the late upper paleolithic people of Tam Hang (Northern Laos): Social identity, mortuary practice, and oral health. *American Journal of Physical Anthropology*. doi: 10.1002/ajpa.22988
- Wilshaw, A.
2016 The Current Status of the Kenya Capsian. *African Archaeological Review*, 33(1):13-27.
- Wobst, H. M.
1977 Stylistic behavior and information exchange. In *For the director: Research essays in honor of James B. Griffin*, edited by C. E. Cleland (pp.317-42). University of Michigan Press.

- 2000 Agency in (spite of) material culture. In *Agency in Archaeology*, edited by M. A. Dobres and J. E. Robb, pp.40-50. New York: Routledge.
- Woldekiros, H.
2014 *The Afar Caravan Route: Insights into Aksumite (50 BCE-CE 900) Trade and Exchange from the Low Deserts to the North Ethiopian Plateau*. Ph.D Dissertation, University of Washington in Saint Louis.
- Wood, D., Bruner, J.S. and Ross, G.
1976 The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, 17(2):89-100.
- Woodhall, D., Clarke, C., Mwangongo, F., Korio, R., & Ndogo, M.
1988 Geological Map of Longonot Volcano, the Greater Olkaria and Eburru Volcanic Complexes and Adjacent Areas. Nairobi: Ministry of Energy, Geothermal Section, Kenya.
- Woolley, A. R.
2001 Alkaline Rocks and Carbonates of the World Part 3: Africa (pp. 100-142). London: The Geological Society Press.
- Wright, D. K.
2005 New perspectives on early regional interaction networks of East African trade: A view of Tsavo National Park, Kenya. *African Archaeological Review* 22(3):111-140.

2011 Frontier animal husbandry in the Northeast and East African Neolithic: a multiproxy paleoenvironmental and paleodemographic study. *Journal of Anthropological Research* 67(2):213-244.
- Wright, D. K. and Forman, S. L.
2011 Holocene occupation of the Mount Porr strand plain in southern Lake Turkana, Kenya. *Nyame Akuma*, 76(4):47-62.
- Wright, D. K., Forman, S. L., Kiura, P., Bloszies, C., & Beyin, A.
2015 Lakeside view: Sociocultural responses to changing water levels of Lake Turkana, Kenya. *African Archaeological Review* 32(2):335-367.
- Wright, J.
2007 Organizational Principles of Khidigsuur Monuments in the Lower Egiin Gol Valley, Mongolia. *Journal of Anthropological Anthropology* 26:350–365.
- Wylie, A.
1985 The reaction against analogy. *Advances in Archaeological Method and Theory* 8: 63-110.

- 1989 Archaeological cables and tacking: the implications of practice for Bernstein's 'options beyond objectivism and relativism'. *Philosophy of the Social Sciences* 19:1-18.
- 2002 *Thinking from things: Essays in the philosophy of archaeology*. Berkeley: University of California Press.
- Wynne-Jones, S.
2007 Creating urban communities at Kilwa Kisiwani, Tanzania, AD 800-1300. *Antiquity* 81(312):368-380.
- Yellen, J.
1998 Barbed bone points: tradition and continuity in Saharan and sub-Saharan Africa. *African Archaeological Review* 15(3):173-198.
- Young, T. P.
1996 High montane forests and afro-alpine ecosystems. In *East African ecosystems and their conservation*, edited by T. R. McClanahan and T. P. Young, pp. 401-424. New York: Oxford University Press.
- Young, R. and Thompson, G.
1999 Missing plant foods? Where is the archaeobotanical evidence for sorghum and finger millet in East Africa? In *The Exploitation of Plant Resources in Ancient Africa*, edited by M. van der Veen, pp. 63-72
- Zedeno, M.
2008 The archaeology of territory and territoriality. In *Handbook of landscape archaeology*, edited by B. David and J. Thomas, pp.210-217. New York: Routledge.
- Zipkin, A. M.
2015 *Material symbolism and ochre exploitation in Middle Stone Age East-Central Africa*. Ph.D. Dissertation, The George Washington University.
- Zvelebil, M.
2009 Mesolithic societies and the transition to farming: problems of time, scale, and organization. In *Hunters in Transition: Mesolithic societies of temperate Eurasia and their transition to farming. New Directions in Archaeology*, edited by M. Zvelebil, pp.167-188. Cambridge: Cambridge University Press.